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Official Rules and Mission for the 6th Annual International Autonomous Underwater Vehicle Competition

**August 7-10, 2003
Space and Warfare Systems Center
San Diego, CA**

GOAL

The goals of this competition are to advance the state-of-the-art of Autonomous Underwater Vehicles (AUVs) by challenging a new generation of engineers to perform realistic missions in the underwater environment and to foster ties between young engineers and the organizations developing AUV technologies.

Event	Due Date
Intent to Compete Form and Payment Due	May 2, 2003
Journal Paper, Website and Resumes Due	July 18, 2003
Teams Check-in Onsite	Wednesday, August 6, 2003
Safety Inspections and In-water Practice Time	Thursday, August 7, 2003
Static Judging and In-water Practice Time	Friday, August 8, 2003
Qualifying Runs	Saturday, August 9, 2003
Qualifying Runs (a.m.) / Finals (p.m.)	Sunday, August 10, 2003
Awards Party (evening)	Sunday, August 10, 2003
Weather Day (if needed)	Monday, August 11, 2003

POINTS OF CONTACT:

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SCHEDULE

Teams register on the morning of August 7 with practice in the arena on August 7 and 8. Each team will participate in the preliminary round on August 9 and 10. Three to five teams will be selected to compete in the finals round to take place on the afternoon of August 10.

MISSION

The mission is for an AUV to demonstrate its autonomy by locating a bulls-eye target on the floor of the arena (Figures 1–3) and depositing a small marker onto the target (Figure 4). There will be three of the bulls-eye targets, but only one will be active for any given run of an AUV. There will be a cluster of three arrows placed in the arena, each arrow pointing to a target (the decision point). Just behind the base of each arrow will be a bright cyan-colored light shining up toward the surface of the water. The active target will be identified by which lamp is lit. As in past years, each vehicle must begin the run by passing through a validation gate.

Conceptually, the mission breaks into three phases:

- 1) *Base vehicle operation:* The vehicle must demonstrate its capability to operate in a controlled manner by passing through a validation gate before attempting any other portion of the course. A team may choose to have a diver aim their vehicle at the gate (Figure 5).
- 2) *Autonomous sensing and decision making:* After passing through the gate, a vehicle must proceed on to the decision point. The decision point consists of a set of three arrows, each with a light associated with it (Figure 6 shows a single light/arrow pair). For each competition dive of a vehicle, the direction to the active target will be indicated by the arrow whose light is lit.
- 3) *Autonomous sensing and action:* Once it has traveled to the active target, each vehicle may drop one or two markers onto the target. Each team is responsible for the design and manufacture of its marker, which must conform to the specifications below.

Time limit: The mission must be completed within 15 minutes of operations. Bonus points are awarded for unused time when a vehicle has placed at least one marker onto the designated target and ended its mission.

ARENA

Splitting the Arena: Various aspects of the arena are presented in Figures 1–3. To increase the number of teams that can practice at any given time, we will operate

vehicles in both halves of the arena at once. There will be a practice configuration of the course, as shown in the left half of Figure 3. During the practice days, both sides will be arranged in the practice configuration.

For the qualifying round, one side of the arena will be changed to the competition configuration, as shown in the right half of Figure 3. If our staffing permits, teams that have not yet made their qualifying run will be allowed to practice during the qualifying runs. Any pingers on the practice side may be turned off when there is a team competing in the other half of the pond. For the finals round, only the competition side will be in use.

Starting Point: Each vehicle will be launched from the starting point, whose approximate location is indicated on the arena plan.

Weight and Size Constraints: For the 2003 competition, each vehicle must weigh less than 100 kg in air. At launch, the unit must fit within a six-foot long, three-foot wide, and three-foot high box. Any vehicle that exceeds these limits will be penalized as set forth in Table 1. For the 2004 competition, the weight limit for vehicles will be reduced to 32 kg (approximately 70 lbs).

Placement of Competition Elements in the Arena: The launch point, gate, and decision point will be placed (as best we reasonably can) along a straight line.

There will be three direction arrows (Figures 3 and 6) near the decision point. Each will indicate the approximate bearing from the decision point to a target. Teams will be told in advance which arrow corresponds to which target (e.g., left arrow for left target). A light will be placed 6 to 18 inches away from the base of each arrow, on the axis of the arrow, as shown in Figure 6.

Marker Specifications: A vehicle may carry up to two markers. Each marker must fit within a box 6 inches long and 1.5 inches on the other two sides and must weigh no more than 1.5 lbs in air. Any marker that exceeds these limits by more than 10% will disqualify that vehicle. Any marker that exceeds these limits by less than 10% will result in a 500-point penalty. Markers will be cleared from the targets after each run.

Lights: Each of the three large indicator lights at the decision point will be an array of at least 100 Superflux™ LEDs (produced by Lumileds, Inc.) mounted inside a waterproof housing with a transparent top. The array will have a peak intensity of at least 200 candela. The particular part number used is HPWN-MC00, and one distributor for this part is Future-Active Electronics (<http://www.future-active.com>).

Acoustics: We are considering placing an acoustic pinger near each target to help vehicles to home from the decision point to the target. We will announce our decision on the use of acoustics by or on April 15.

If we use pingers, up to four active pingers may be in the water at a time, each operating on its own frequency in the 20–40-kHz band.

The pingers would be synchronized rather than free-running. For example, with four units all pinging once per second, the schedule might be:

- Unit 1 pings at 23 kHz at time $t = 0.0$ second,
- Unit 2 pings at 25 kHz at time $t = 0.2$ second,
- Unit 3 pings at 27 kHz at time $t = 0.4$ second,
- Unit 4 pings at 29 kHz at time $t = 0.6$ second,
- Unit 1 pings at 23 kHz at time $t = 1.0$ second.

If acoustics are used, the precise schedule will be published on April 15.

OFFICIAL RULES, SUBMISSIONS, AND FEES

1. The official source for all information concerning rules, interpretations, and information updates for the 2003 International Autonomous Underwater Vehicle Competition is the World Wide Web home page at:
<http://www.auvsi.org/competitions/water.cfm>.
2. **An Intent to Compete form, available on the website, and the entry fee are due no later than May 2, 2003.** The submission must be in English and is not considered official until the entry fee of five hundred U.S. dollars (\$500) has been received by AUVSI. As the competition format cannot handle an unlimited number of entries, the organizers reserve the right to limit the total number of entries that are allowed to compete by declaring the competition closed to new entries before the due date above. As with all official information, this announcement (should it be necessary) will appear on the official website.
3. The vehicle must operate autonomously, with no control, guidance, or communication from a person or any off-board computer (including the GPS constellation).
4. Teams must submit a journal paper and a website for evaluation by the judges.
5. There will be a preliminary round that all teams will compete in. After the preliminary round, the judges will convene and tally their scores. The judges have the discretion to select the number of teams entering the finals as they deem appropriate. Teams will be accepted into the finals round in rank order from the preliminary round. We anticipate that three to five teams will be accepted into the finals.
6. After the competition, the judges will issue overall standings. Any team that is accepted in the finals round will be ranked ahead of all teams that are not accepted into the finals round.
7. Each team will have 20 minutes on the dock. The first 5 minutes constitute the preparation period. During this time, the vehicle may not be deployed in the water. The 15-minute-long performance period immediately follows.

Preparation period: A team may waive a portion of the 5-minute-long preparation

period and start the 15-minute-long performance period. Once the performance period starts, the team loses any unused time in the preparation period.

Performance period: When the officials signal the start of the performance period, the team may ask to have the vehicle deployed into the water and released to perform the mission. Only tournament officials may deploy and recover the vehicle. The time required to deploy and/or recover does not count against the 15-minute limit. This is to prevent unsafe actions in an attempt to speed the deployment and recovery processes.

8. *Multiple runs:* A team may attempt multiple runs during the performance period. Once a team has the officials redeploy their vehicle, all points earned in previous runs are lost.
9. *Ending a run and retrieving a vehicle:* At any time while a vehicle is running, the team captain can request the end of the run and the retrieval of the vehicle. Only officials may retrieve a vehicle and return it to the dock. The clock for the performance period stops when the official touches the vehicle to recover it. Once the vehicle is safely on the dock, the clock for the performance period resumes.

If a vehicle experiences a significant interference from a piece of equipment, line, cable, or diver deployed in support of the competition, the team captain may ask **at that time** to have the clock stopped, the vehicle returned to the dock, and for the judges to add back to the clock their best estimate of the time used in that run up to the point of interference. If the team captain does not make this request in a timely manner (as determined by the technical director or his designee), then the option is lost. Interference with a gate, arrow, light, or target object does not qualify for this option, and a vehicle interfering with those items may be disqualified at the judges' discretion.

10. The mission ends when any of the following occur:
 - The 15-minute performance period ends.
 - The judges order the end of the mission.
 - The team captain requests the end of the mission.
 - The vehicle breaches the surface (as determined by the judges).

VEHICLES

1. Each team may enter one vehicle into the competition. Each vehicle will be physically inspected by the competition judges. The judges may disqualify any vehicle that they deem to pose an unreasonable safety hazard.

The judges will confer with representatives of the host facility, and any vehicles that, in the opinions of the judges or the representatives of the host facility, pose an unreasonable risk to the integrity of the host facility will be disqualified. The AUVSI and the host organization, their employees and agents, as well as the organizing committee, are in no way liable for any injury or damage caused by any vehicle, nor for any damage or injury caused directly or indirectly by the disqualification of an vehicle.

2. Each vehicle must operate autonomously during its dive. While carrying out the mission, no communication is permitted between the vehicle and any person or off-board computer. Vehicles must operate solely on their ability to sense and maneuver in the arena using on-board resources.
3. The mass of each vehicle must be less than 100 kg. Note that bonus points are awarded to vehicles that are below this limit, and penalties assessed for those that exceed it (Table 1). The entire vehicle must fit within a box that is 6 feet long, 3 feet wide, and 3 feet deep.
4. All vehicles must be battery powered. All batteries must be sealed to reduce the hazard from acidic or caustic electrolytes. Batteries may not be charged inside of sealed vessels at any time while on the site of the competition and/or while engaged in the competition. The open circuit voltage of any battery in an vehicle may not exceed 60 VDC. If a team has any questions or concerns, they are encouraged to contact the organizing committee.
5. No materials (except for the markers and compressed air used to blow ballast) may be released by the vehicle into the waters of the arena.
6. All vehicles must bear a clearly marked kill switch that a diver can readily activate. This switch must disconnect the batteries from all propulsion components and devices in the AUV. All vehicles must be buoyant by at least one half of one percent (0.5%) of their mass when they have been shut off through the kill switch.
7. Teams may comprise a combination of students, faculty, industrial partners, or government partners. Students may be high school, undergraduate and/or graduate students. Interdisciplinary teams are encouraged. Members from industry, government agencies, or universities (in the case of faculty) may participate; however, full-time students must compose at least 75 percent of each team. Participants must be enrolled at their schools for at least 12 credit hours or more per quarter/semester during winter and spring 2003 to be considered "students." The student members of a joint team must make significant contributions to the development of their vehicle. ***Only the student component of each team is eligible for the cash awards.***

One student member of the team must be designated as the "team captain." The team captain, and only the team captain, will speak for the team during the competition run.

8. No team member is allowed to enter the arena at any time (this includes wading, swimming, and diving as well as floats, boats, etc.). Competition officials will be responsible for recovering lost vehicles that cannot be safely reached from the starting point. Officials will make all reasonable efforts to recover a lost vehicle but cannot guarantee that they will be able to do so. All teams recognize that by entering the competition, they risk damage to or the loss of their vehicle. The judges, officials, hosts, and sponsors can take no responsibility for such damage or loss.

9. The officials will suspend the operation of a vehicle at any time they deem that it is required by safety or security considerations. Teams may be required to submit technical descriptions of their vehicles to the officials in advance of the competition, with the goal of identifying potential safety concerns well in advance. When requested, such technical information submitted to the judges will be held in confidence until the end of the competition.

10. The officials will suspend the competition at any time they deem that it is required by safety or security considerations.

JOURNAL PAPER

Each team is required to submit a journal paper that describes the design of their vehicle and the rationale behind their design choices. This paper may be no more than 10 pages long (including all figures, references, and appendices). Additionally, each journal paper must include an abstract of no more than 250 words. The journal paper and abstract must be printed on standard 8.5 × 11-inch paper, with margins of at least 1 inch on all sides, and all text must be in 12-point or larger font. Each page must bear a footer with the page number and the team name. The journal paper will be evaluated as described below in the section on scoring.

The journal paper must be received in electronic format (pdf is preferred) via email. Papers are due one week before the competition date. Teams that do not meet the deadline may be disqualified from the competition.

STATIC JUDGING

Each vehicle will be subject to static judging before being allowed to compete. During the static display time, each team will be visited by the judges, and by the public, the press, and representatives of other organizations. The judges will evaluate each vehicle for technical merit, safety, and craftsmanship as described below in the section on scoring. Each team is required to have at least one member attending their vehicle throughout the static display period (not just during the judges' scheduled visit). Teams are also strongly encouraged to make a poster describing the vehicle. The posters can be set up next to the vehicle during the static display period. Representatives of the press and of other organizations will be encouraged to visit each team during this period.

ONSITE EXPECTATIONS

The organizers have made every attempt to provide the competitors with maximum resources at the Competition site, including electrical power, test pools, Internet access, and practice time in the main pool. This event is not only opened to the public

TEAM WEBSITES

Each team is required to create a website for their vehicle entrant and corresponding effort. In the months leading up to the event, the judges may choose to use team websites for additional information. Please keep in mind that team websites must be open to the public.

RESUMES

One goal of the competition is to foster links between young engineers and the companies, universities, and government agencies involved in AUV development. To advance that goal, we request that each team provide resumes of each team member, along with class year and expected graduation date. These resumes (when submitted) will be circulated to our sponsors, employers who will be considering opportunities for full-time employment and internships and co-op programs. Your participation in this new program is strongly encouraged. Electronic versions of team member resumes should be appended to the journal paper.

SCORING

Vehicles will be scored on performance measures and on subjective measures. The point value for the various elements of the competition are listed in Table 1.

Table 1. Points awarded for the Competition.

<i>Performance Measures</i>	<i>Points</i>
Dry weight less than 100 kg	2 points per kg under 100
Dry weight greater than 100 kg	penalty of $-[500 + 20 \cdot (\text{weight} - 100)]$
Each marker exceeding a weight or dimensional specification by no more than 10%	penalty of 500 per specification exceeded per marker
Pass through the validation gate	250
Each marker placed onto a tray of the active target	500, 1,000, or 1,500
Finish the mission with T minutes (whole or fractional) remaining of the time allotted for the task	$T \times 100$
<i>Subjective Measures</i>	<i>Max. Points</i>
Utility of team website	50
Technical merit (from journal paper)	50
Written style (from journal paper)	50

Technical merit (from static judging)	75
Craftsmanship (from static judging)	75
Team uniform (from static judging)	10
Discretionary points (awarded after static judging)	40
Discretionary points (awarded after last competition run in preliminary round and again in finals round)	250

All performance point totals are set to zero at the start of the finals round. In other words, the final point total for a team that is accepted into the finals round is the sum of all points awarded to that team except those awarded for performance in the preliminary round as well as any discretionary points awarded in the preliminary round. At the end of the finals round, the judges may award up to 250 discretionary points as they see fit to the teams accepted into the finals round.

Of the teams that are accepted into the finals round, the one that ends the competition with the greatest number of points will be declared the winner.

Technical merit and craftsmanship: These considerations will exclude any components of the design that are or could be (in the opinion of the judges) commercially available or do not include a significant contribution by team members. In other words, if you use a well-built, well-designed, off-the-shelf computer, your team does not get points for the computer's good technical design. You will get points for selecting a computer that is, in the opinion of the judges, well suited to the engineering needs of the vehicle.

Passing through the validation gate: The judges will use their discretion in making their determination. Partial points may be awarded.

Dropping a marker on the active target: The judges will use their discretion in making their determination and will be aided by the dive team. Partial points may be awarded.

Unused time: The judges will record the time elapsed between the start of the 15-minute-long period allotted for vehicle performance and the end of the mission. Unused time (in minutes) will be rounded up to the nearest integer greater than or equal to the unused time (e.g., 0m 01s will be rounded to 1 minute; 14m 59s will be rounded to 15 minutes; 5m 00s will be 5 minutes). The points for unused time will only be awarded if the complete mission is accomplished (i.e., the vehicle places at least one marker onto a tray of the active target).

SEQUENCE OF EVENTS DURING THE COMPETITION

Static display period: Each team will receive a visit from the judges during this period for the static judging. Additionally, members of the public, the press, and representatives of

other organizations will be encouraged to view the vehicles and talk with team members.

Each team will have a series of visits from the judges during scheduled time periods. The judges may work together in small groups.

Practice runs: Practice time slots will be scheduled on an ad hoc basis by the technical director or his designee during the two practice days. It is our intent to provide as much practice time in the arena as is practical and to ensure minimal idle time for the arena. Each vehicle must be approved by the technical director or his designee before it will be allowed into the arena.

Time slots announced for competition runs: Competition time slots will be awarded based on standings after the static judging. The team that is in first place will have first choice, etc. Ties will be broken by a coin toss or random draw.

Preliminary round of the competition: Each team will be assigned a time slot to perform the mission. Twenty minutes before the beginning of their time slot, the team may enter the staging area near the launch site. At the beginning of their time slot, the team may move to the launching site on the dock. The first 5 minutes are for preparation. During this period, the vehicle may not be deployed in the water. When the 5-minute limit has expired (or the team has waived the balance of the preparation time), the judges will begin a 15-minute clock. These 15 minutes are for vehicle to perform the mission. Once this period has begun, the team may ask to have their vehicle placed in the water to begin its mission.

Vehicles will be put into and taken out of the water by tournament officials. The time required to do so will not count against the 15-minute limit. If a vehicle is in the water, the team may request that it be lifted onto the dock. Tournament officials will move the vehicle onto the dock and (when requested) redeploy the AUV into the water. Again, the time required to move the vehicle into and out of the water will not count against the 15-minute limit. However, time spent by the team on the dock does count against the 15-minute limit.

The mission will continue until the 15-minute limit has expired, or the team captain requests the end of the mission, or the judges order the termination of the mission, or the vehicle breaches the surface. The judges may order termination of the mission at their discretion. Once the judges order the end of the mission, no further points may be scored. The judges' decisions on the termination of the run are final.

Finals round of the competition: After the preliminary round, the judges will tally their scores. Teams will be accepted into the finals in rank order from the preliminary round. The judges have the discretion to select the number of teams entering the finals as they deem appropriate. We anticipate three to five teams competing in the finals. The finals round will be conducted in the same manner as the preliminary round.

AWARDS

Cash prizes of up to \$20,000 will be awarded at the discretion of the judges.

DIAGRAMS

Figure 1: Aerial photo of the facility. The water clarity shown is typical. The bridge structure has no piers or supports in the pond and does not obstruct the water.

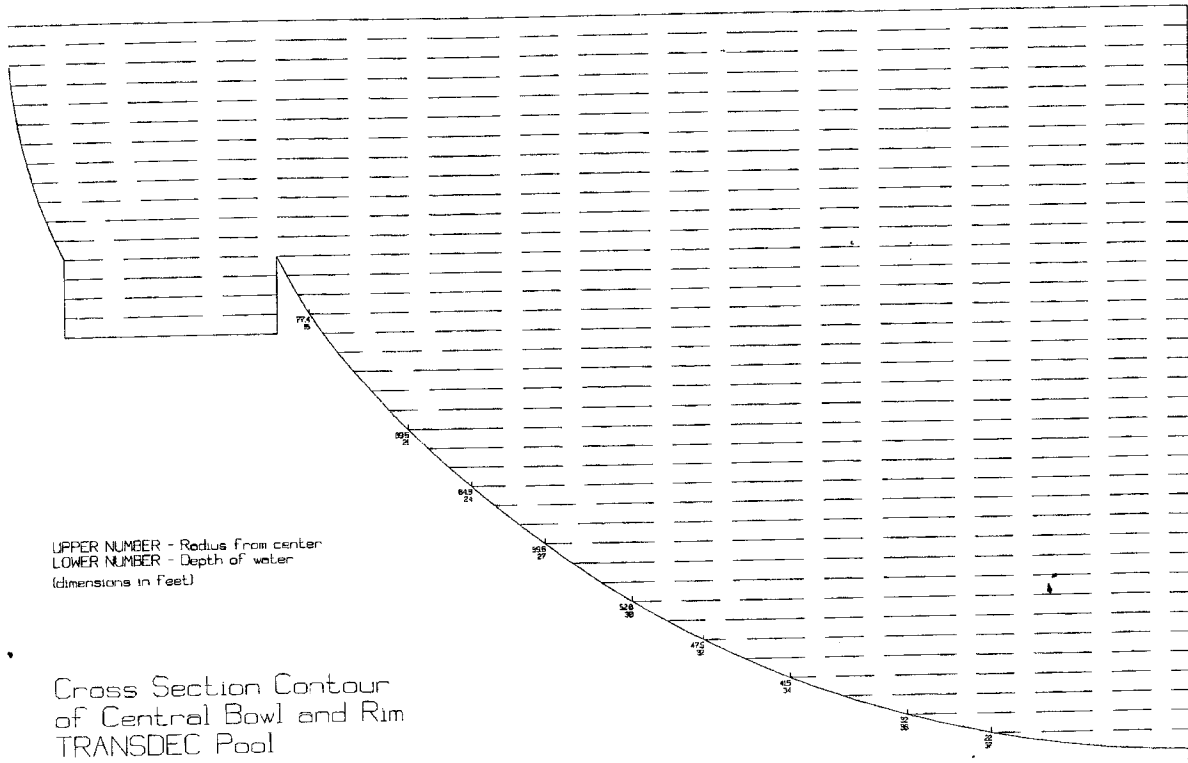


Figure 2: Cross section of arena showing the depth profile. Note that the acoustic trap (the 16-foot-deep section around the perimeter) varies in width around the pond (Figure 1). Table 2, below, lists the numbers from this Figure for the bowl dimensions.

Table 2: Depth of bowl at various radii from its center.

Radius	0	22	32	41.5	47.5	52.8	59.5	64.9	69.5	77.4
Depth	38	37	35	34	32	30	27	24	21	15

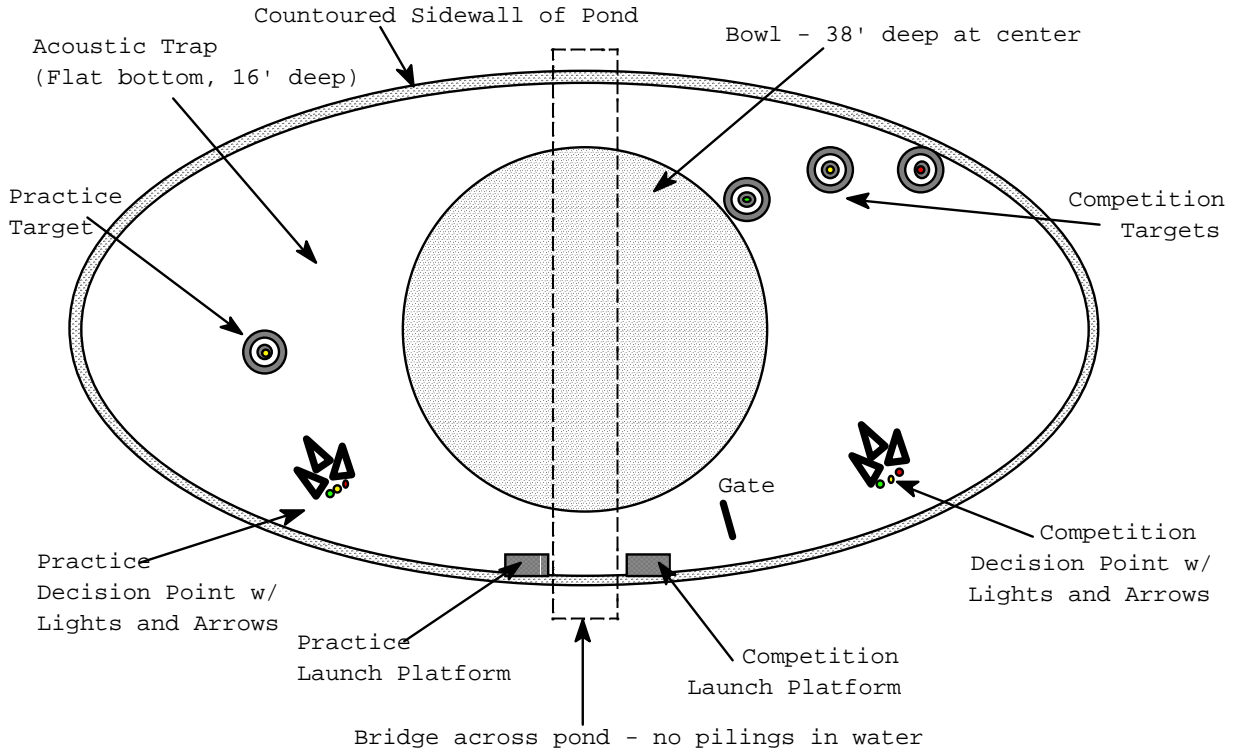


Figure 3. Possible layout of the arena. The arena is split into a competition side (right half of this view) and a practice side (left half). On the competition side, the indicator lights are equidistant from the three targets. All targets will be in the acoustic trap. At the decision point, the arrow/light pairs will be spaced two to four feet apart.

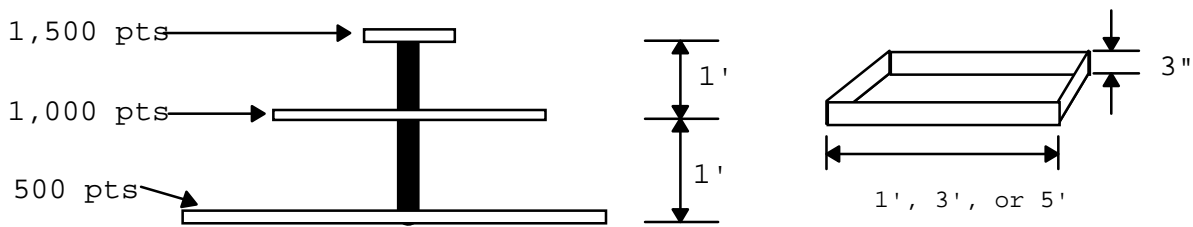


Figure 4. Target details. Each target consists of three square trays stacked on a support, as shown in the left image. Each tray has a sidewall (rim) that is 3" tall, as shown in an oblique view in the right image. The bottom of each tray is made of 0.24-inch-thick foamed PVC bolted onto a supporting structure. The highest and lowest trays will be white, the middle tray will be black. Each marker on a tray of the active target will earn the points shown. A bright LED (one 1-W cyan Lumiled LED) will be mounted into the center of the highest (and smallest) square.

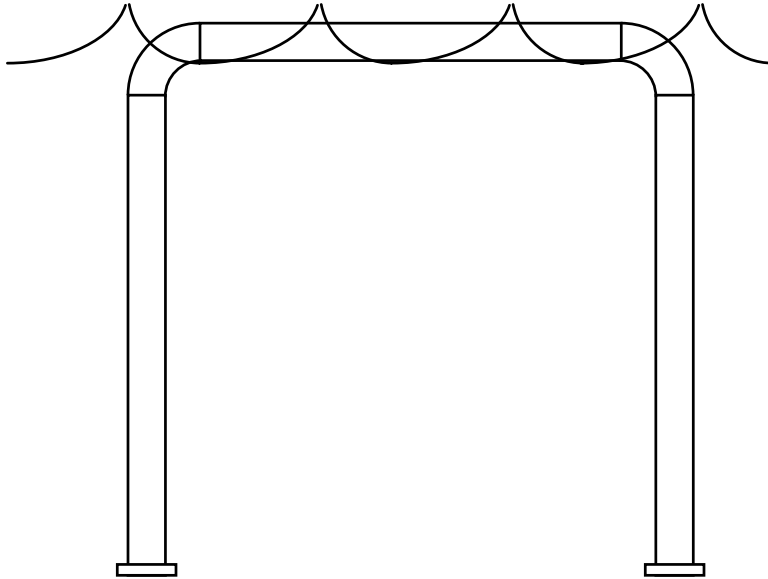


Figure 5: Validation gate. It is constructed of 4-inch-diameter white PVC pipe. It is 10 feet wide and each leg is six feet long. It will be buoyant, and will be anchored to the bottom by lines.

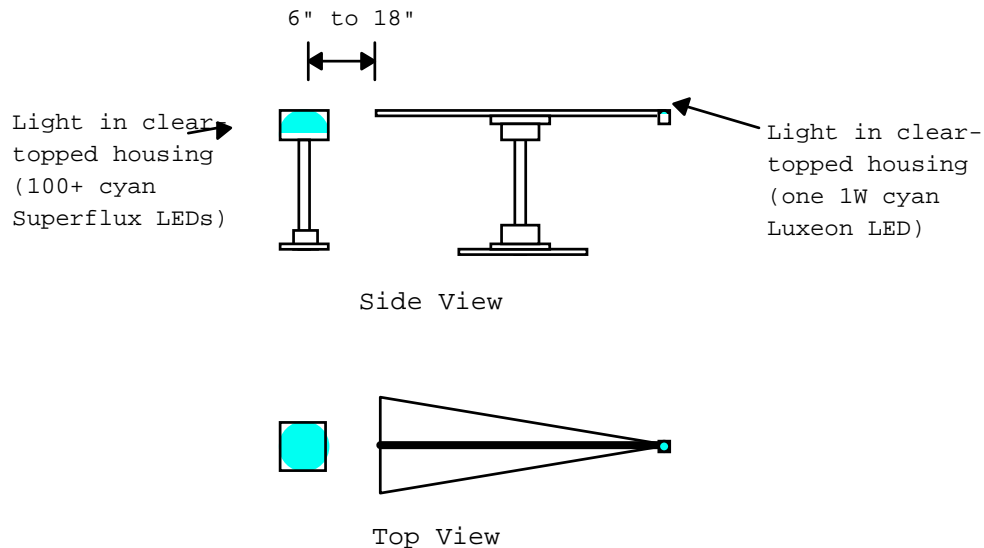


Figure 6. Arrangement of one arrow and indicator light at the decision point. The 2-foot-long, 8-inch-wide arrow is made of 0.24-inch-thick, white foamed PVC. There is a one-inch-wide black stripe along its axis. The larger lamp is in a clear-topped housing approximately one-foot square. The small light is in a small, clear, cylindrical housing about 2 inches in diameter.