

The Association for Unmanned Vehicle Systems International (AUVSI) and the
U.S. Office of Naval Research (ONR)
Announce the

**Rules for the
4th Annual International
Autonomous Underwater Vehicle
Competition
July 11-15, 2001
U.S. Naval Academy
Annapolis, Maryland**

GOAL and COMPETITION OVERVIEW:

The goal of this competition is 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.

Many applications for AUVs require measuring or mapping the bathymetry of the seafloor. Identifying the shallowest item in an array of man-made objects is the first step towards this capability. Additionally, numerous operational missions require finding and recovering objects on the seabed. The organizers expect these fundamental capabilities to be the foundation for future Competition scenarios, with the degree of difficulty increasing each year proportionate to the degree of entrant proficiency.

KEY MILESTONES:

Event	Due Date
Intent to Compete Form and Payment Due	April 30, 2001
Journal Paper, Website and Resumes Due	June 15, 2001
Teams Check-in Onsite	July 11, 2001
Static Judging and Safety Inspection	July 11, 2001
Practice Time	July 11-13, 2001
Competition	July 15, 2001

POINTS OF CONTACT:

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ARENA:

SITE: The U.S. Naval Academy will be the host of this year's Competition. The exact location of the water and the accompanying logistical accommodations will be made available in separate correspondence.

BEACONS: Each beacon will be equipped with a pinger (an acoustic transmitter), a light source (strobe) and a recovery marker (Figure 1).

When activated, the pinger will transmit a short acoustic pulse on a pre-set frequency every 20 to 40 seconds. Similarly, every 1 to 2 seconds, the light will flash. (The light is not synchronized to the pinger).

STARTING POINT: Each entry will be launched from a dock, which will be indicated on the arena plan, once located. **VALIDATION GATE** A gate (Figure 2) will be placed 12 to 18 feet from the starting point and must be initially and successfully traversed as part of the mission.

BOTTOM TOPOGRAPHY: There will be a number of man-made objects in linear arrays placed on the bottom of the arena in water that is approximately 10-12 feet deep. Each object will be one to four feet high and approximately 2 feet square (Figure 3). One of the objects in each line will be shallower (distance from the water surface) than the others. Each linear array will have a beacon at one end. Figure 3 shows one possible arrangement of the arrays and beacons. (In future years, the distribution of objects may be less ordered, making the mission more difficult.)

MISSION:

1. The complete mission objectives are for a self-propelled, autonomous vehicle to leave the starting point in the arena, pass through the validation gate, find the active object array (indicated by an acoustic beacon and map location), determine the shallowest depth in the active array, determine the ping rate of the beacon, and recover a marker at the beacon before time runs out. Points are awarded (Table 1) for accomplishing parts of the mission in any order after passing through the validation gate. In the case of a tie in total points, the entry that completes the mission in the least time will win.

On the morning (0700) of the competition, the officials will arrange a final configuration of beacons and associated topography arrays within the arena, and post a final configuration map near the starting point. One hour before an entry begins its mission, the team will be notified which beacon will be activated for their run.

2. The vehicle must accomplish all parts of the mission autonomously, with no control, guidance, or communication from a person, or from any off-board computer (including the GPS constellation).

3. Each team will have 40 minutes on the dock. The first 10 minutes are the preparation period. During this time the entry may not be deployed in the water. The 30-minute-long performance period immediately follows.

When the officials signal the start of the performance period, the team may ask to have the entry 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 30-minute limit. This is to prevent unsafe actions in an attempt to speed the deployment and recovery processes.

A team may attempt multiple runs during the 30-minute performance period. Once a team has the officials re-deploy their vehicle, all points earned in previous runs are lost. Only officials may retrieve a vehicle and return it to the dock. The clock stops when the official touches the vehicle.

4. The mission ends when any of the following occur.
- i) All objectives have been achieved.
 - ii) The 30-minute performance period ends.
 - iii) The Judges order the end of the mission.
 - iv) The Team Captain requests the end of the mission.

OFFICIAL RULES, SUBMISSIONS, and FEES:

The official source for all information concerning rules, interpretations, and information updates for the 2001 International Autonomous Underwater Vehicle Competition is the World Wide Web Home Page, <http://www.auvsi.org/auvcomp.htm>.

An Intent to Compete form, available on the web site, and entry fee is due no later than April 30, 2001.

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. The competition format cannot handle an unlimited number of entries. Therefore, 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 web site.

VEHICLES:

1. Each team may enter one vehicle into the competition. Each entry will be physically inspected by the competition judges. The judges may disqualify any entry that they deem to pose an unreasonable safety hazard. The judges will confer with representatives of the host facility and any entries that, in the opinions of the judges or of the representatives of the host facilities, 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 entry.

- 2. Each entry must be autonomous. While carrying out the mission, no communication is permitted between the entry and any person or off-board computer. Entries must compete solely on their ability to sense and maneuver in the Arena using on-board resources.**
- 3. The mass of each entry must be less than 100kg. Note that bonus points are awarded to vehicles that are below this limit (Table 1). The entire vehicle must fit within a box that is six feet long, three feet wide, and two feet deep.**
- 4. All entries 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 entry may not exceed 60 VDC. If a team has any questions or concerns, they are encouraged to contact the organizing committee through the web site.**
- 5. No materials (except for compressed air used to blow ballast) may be released by the entry into the waters of the Arena.**
- 6. All entries 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 entries must be buoyant by at least one half of one percent of their mass when they have been shut off through the kill switch.**
- 7. Teams may be comprised of a combination of students, faculty, industrial partners, or government partners. Students may be 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 comprise 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 2001 to be considered "students". The student members of a joint team must make significant contributions to the development of their entry. Only the student component of each team will be eligible for the cash awards. One 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, swimmers and diving as well as floats, boats, etc.). Competition officials will be responsible for recovering lost entries that cannot be safely reached from the starting point.**
- 9. The officials will suspend the operation of a vehicle at any time they deem that such action is required by safety or security considerations. Teams may be required to submit technical descriptions of their entries 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 entry and the rationale behind their design choices. The paper may be no more than 10 pages long (including all figures, references, and appendices). Additionally, each Journal Paper must include an Abstract of 250 words or less. The paper must be printed on standard 8.5" by 11" paper, with margins of at least 1" 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 by June 15, 2000. Teams that do not meet the deadline may be disqualified from the Competition.

STATIC JUDGING:

Each entry will be subject to static judging before being allowed to compete. During the static display time, each team will be visited by the judges. They will evaluate each entry 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 entry throughout the static display period (not just during the scheduled visit by the judges). Teams are also strongly encouraged to make a poster describing the entry. The posters can be set up next to the entry during the static display period. Representatives of the press and of other organizations will be encouraged to visit each team during this period.

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 your website for additional information. Please keep in mind that your website must be available to the public (and other entrants). The website must initially be ready for access by June 15, 2001. Obviously, you can update the site as often as you would like.

RESUMES:

AUVSI is initiating a new program this year to facilitate exposure of competition team members to prospective employers (government and industry). As part of this program, we are requesting that each team provide resumes of each team member, along with class year and expected graduation date. Employers 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, both of which are due by June 15, 2001.

SCORING:

Entries will be scored on performance measures and on subjective measures.

Technical Merit and Craftsmanship: These considerations will exclude any components of the design that are or could be (in the judges opinion) 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 well suited to the engineering needs of the design, in the opinion of the judges.

Travel and Dive Fully Autonomously: The judges will use their discretion in making their determination. Partial points may be awarded. No points will be awarded for determining the shallowest depth, or for returning the recovery marker unless full points are awarded for this task.

Table 1: Scoring for the Competition

<i>Performance Measures</i>	<i>Max. Points</i>
Dry weight less than 100 kg	2 points per kg under 100
Determine the ping rate of the beacon	150
Passes through the validation gate under clear autonomous control	300
Return the recovery marker to the starting point	1000
Determine the depth of the shallowest object	1000
Finish the mission with T minutes (whole or fractional) remaining of the 30 minutes allotted for the task	T * 20
<i>Subjective Measures</i>	<i>Max. Points</i>
Utility of Team Web Page (on or after 15 June 2001)	100
Technical Merit (from Journal Paper)	100
Written Style (from Journal Paper)	100
Technical Merit (From Static Judging)	150
Craftsmanship (From Static Judging)	150
Team uniform (From Static Judging)	10
Discretionary Points (Awarded After Static Judging)	40
Discretionary Points (Awarded After Last Competition Run)	100

Return the Recovery Marker: The marker is considered recovered if it is attached to the vehicle at the end of the mission. The complete mission includes returning the marker to the starting point. The judges will use their discretion in making their determination. Partial points may be awarded.

Determining the Ping Rate and Shallowest Depth: Teams may connect a computer to the vehicle and recover this information. They may do so during the performance time, or as soon as is practical after the 30-minute performance time expires. The judges will use their discretion in making their determination. Partial points may be awarded.

Unused time: The judges will record the time elapsed between the start of the 30-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. 0:01 will be rounded to 1 minute, 29:59 will be rounded to 30 minutes, 5:00 will be 5 minutes). The points for unused time will only be awarded if the complete mission is accomplished.

SEQUENCE OF EVENTS DURING THE COMPETITION:

Note: *The sequence of events is subject to change based on the number of entrants and the availability of in-water time at the site. The number of entrants and the facilities may dictate an extra day is required for practice and/or competition runs.*

Static Display Period: Each team will receive a series of visits from the judges during this period for the static judging. In addition, members of the public, the press, and representatives of other organizations will be encouraged to view the entries and talk with team members.

The order for static judging will be determined based on the standings after the web pages and papers have been scored. Teams will be grouped (by score) into groups of 3 or 4 teams each. The judges will visit all the teams in the first group before going to the second group. Typically, judges will spend 10 to 15 minutes with each team.

Thus, each team will have a series of visits from the judges during a scheduled time period (as many teams requested last year). The judges may work together in small groups (as many judges preferred to do last year).

Practice Runs. Practice time slots will be scheduled based on standings after the web page and journal paper. The team that is in first place will have first choice, etc. Ties will be broken by a coin toss or random draw. Each entry must be approved by the judges before it will be allowed into the Arena. It is our intent to provide as much practice time in the Arena as is practical.

As each group has completed static judging, they will be permitted to start practice runs while the other teams are still undergoing static judging. We expect to allow two entries in the arena simultaneously, on the condition that they not interfere with each other. If

we feel we can safely accommodate more, we will. We anticipate that each team should have approximately 2 hours of practice time.

Time slots announced for the day of the competition. 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.

Competition. Each team will be assigned a time slot. 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 slot, the team may move to the launching site on the dock. The first 10 minutes are for preparation. During this time the entry may not be deployed in the water. When the 10-minute limit has expired the judges will begin a 30-minute clock. These 30 minutes are for vehicle performance. 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 Competition officials. The time required to do so will not count against the 30-minute limit. After the vehicle has gone into the water, the team may request that it be lifted onto the dock for repairs. Again, tournament officials will move the vehicle onto the dock, and (when requested) re-deploy the AUV into the water. Again, the time required to do so will not count against the 30-minute limit. However, time spent by the team on the dock does count against the 30-minute limit.

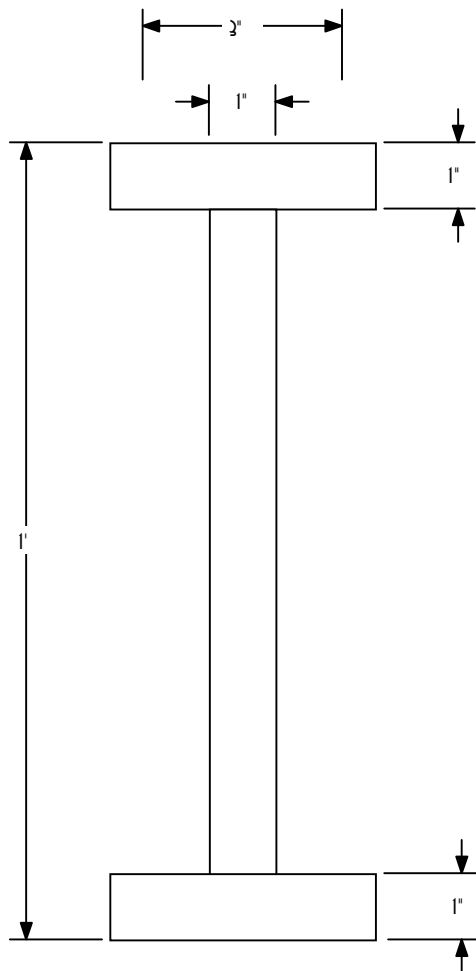
The mission will continue until all objectives have been achieved, the 30-minute limit has expired, the Team Captain requests the end of the mission, or the judges order the termination of the mission. The judges may order termination of the mission at their discretion. Once the judges order the end of the mission, no further points may be scored. The judges' decisions on the termination of the run are final.

AWARDS:

Cash prizes of at least \$13,000 will be awarded at the discretion of the judges.

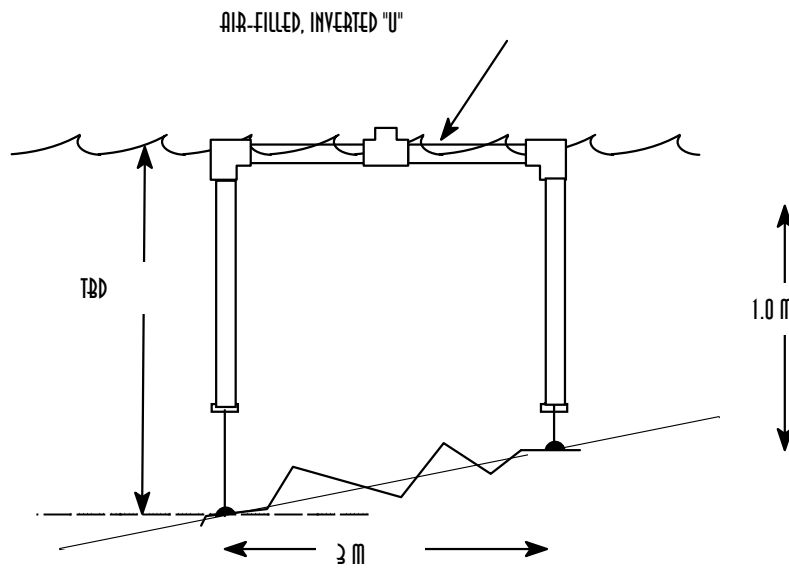
DIAGRAMS:

Figure 1: Recovery Marker



RECOVERY MARKER, REV 2.0
 J. BALES, 22 SEPT. '00
 MATERIAL:
 HDPE (DENSITY = 0.95)

NOTES:
 COLOR = WHITE
 EACH END HAS V = 115 (M²)
 COLUMN HAS V = 128 (M²)
 NET BUOY. = 18 G
 STEEL WASHERS BOLTED TO BOTTOM
 TO GIVE NET NEGATIVE BU
 APPROX. 4 OZ.

Figure 2: Proposed Validation Gate

THE APPROXIMATE DIMENSIONS OF THE GATE. THE
"INVERTED U" IS AIR-FILLED 4" DIAMETER (NOM.)
WHITE PVC PIPE.

Figure 3: Typical man-made object. The box is approximately two-feet-long on each side, and one to four feet tall. The heavy lines denote a simple framework (possibly made from PVC pipe). The shaded top is a sonar-reflecting, high-visibility material to be determined.

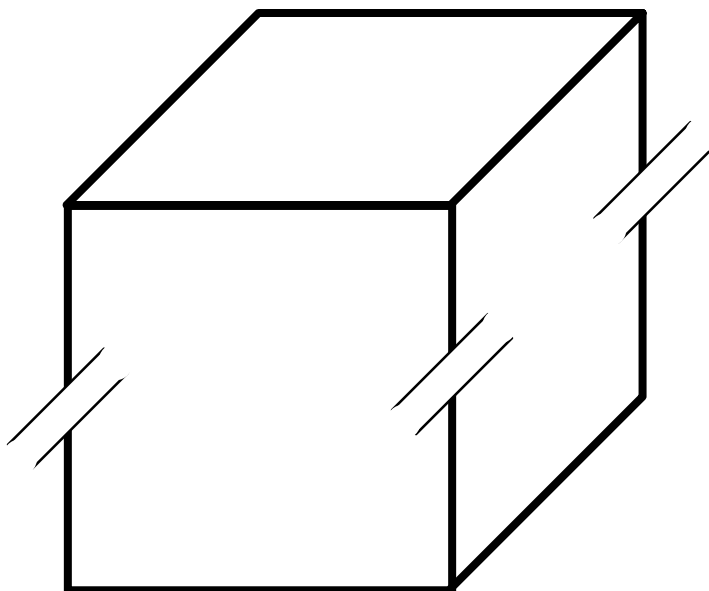


Figure 4: A possible arrangement of the arena.

