Final Mission and Scoring

A Pirate's Life for Thee

19th Annual International RoboSub Competition

www.RoboSub.org

July 25-31, 2016

SSC Pacific TRANSDEC

San Diego, CA

1 Competition Points of Contact

Please direct your comments and questions to the RoboSub Community ("RoboSub 2016" on Google+). Teams are encouraged to participate in the community.

Technical Director:
David Novick: dknovic@sandia.gov

Competition Questions (registration, travel, hotel or team deliverables):
Competitions@AUVSIFoundation.org

2 Reminder

The official source for all information concerning rules, interpretations, and information updates for the International Autonomous Underwater Vehicle Competition (RoboSub) is the World Wide Web home page: www.RoboSub.org. On the main site, you can find information regarding eligibility, registration (the form and fees), websites, social media, journal paper requirements, team presentations & videos and much, much more.

3 Theme

Avast ye land lubbers! Me moniker be Jolly Dave. Th' 19th century saw th' down turn o' buccaneering pirates. Shiver me timbers. Th' 19th RoboSub competition gonna smartly raise the jolly roger 'n embrace our inner scurvy pirate. Don't be a bilge rat, register fer th' competition, or be forced to walk th' plank and give Davey Jones our regards.

4 Mission

The fundamental goal of the mission is for an AUV to demonstrate its autonomy by fulfilling this undertaking as a buccaneering pirate. Orange guide markers will help direct the vehicle to the beginning tasks. Two pingers will guide the AUV to the remaining two tasks. The vehicle will have to scuttle a ship (touch buoys), navigate a channel (pass over an obstacle), weigh anchor (drop a marker), set course (fire torpedoes), and bury a treasure (retrieve an object, surface, move/release the object).

5 COMPETITION OVERVIEW

5.1 Venue

The competition will be held at the SSC Pacific TRANSDEC facility. The large facility allows us to divide the area into sections. The mission will take place in 16ft (4.9m) of water. This year, to accommodate the growing number of teams, we will divide the venue into four sections, and will be running **full** missions in **every** section. During the semi-finals, one half (the competition side, two full sections) will be devoted to the semi-final runs. The other half (practice side, two full sections) will be devoted to teams wishing to continue to polish their algorithms. For the finals, the entire competition side will be devoted to the runs. Therefor the tasks will be spread out over the entire half of the facility.

5.2 Weight and Size Constraints

For the RoboSub competition, each entry must fit within a six-foot long, by three-foot wide, by three-foot high "box" (1.83m x 0.91m x 0.91m). Table 1 shows the bonuses and penalties associated with a vehicle's weight in air

Table 1: Vehicle weight in air with Bonus or Penalties

	Bonus	Penalty
AUV Weight > 125 lbs (AUV Weight > 56.7 kg)	**N/A**	**Disqualified**
125 lbs ≥ AUV Weight > 84 (56.7 kg ≥ AUV Weight > 38)	**N/A**	**Loss of** **250 + 5*(lb – 125)** **250 +11*(kg – 56.7)**
84 lbs ≥ AUV Weight > 48.5 (38 kg ≥ AUV Weight > 22)	**Bonus of** **2*(84 – lb)** **4.4*(38 – kg)**	**N/A**
AUV Weight ≤ 48.5 lbs (AUV Weight ≤ 22 kg)	**Bonus of** **80 + (48.5 – lb)**	**N/A**

5.3 Markers

Each marker must fit within a box 2.0" square and 6" long (5.1 x 5.1 x 15.2 cm). Each must weigh no more than 2.0 lbs (0.91 kg) in air. Any marker that exceeds these limits by less than 10% will result in a 500-point penalty. Any marker that exceeds these limits by more than 10% will be disqualified. Each marker must bear the team name, color or emblem. Markers will be cleared from the arena after each run. A reasonable amount of time will be spent looking for lost markers, however consider them expendable and have backups.

5.4 Torpedoes

The torpedo size, weight, markings and potential "loss" are identical to the Markers. The torpedoes must travel at a "safe" speed. A "safe" speed is one that would not cause a bruise when it strikes a person from close range.

5.5 Pingers

The pingers will be Benthos ALP-365. The Benthos ALP-365 is user selectable from 25 to 40 kHz in 0.5 kHz increments. They will only be set to an integer frequency (25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 or 40).

6 COMPETITION RULES

1. The official source for all information concerning rules, interpretations, and information updates for RoboSub is the World Wide Web home page at: www.RoboSub.org
2. During the competition, the vehicle must operate autonomously, with no control, guidance or communication from a person or any off-board computer. The vehicle and any parts connected to the vehicle must submerge and remain submerged. No item may break the surface or be attached to the vehicle and left floating while the vehicle is underway.
3. Teams may be comprised of a combination of students, faculty, industrial partners, or government partners. 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% of each team. Participants must be enrolled at their schools as a full time student per quarter/semester during winter and spring to be considered "students." The student members of a team are expected to make significant contributions to the development of their vehicle.
4. Only the student component of each team is eligible for the cash awards.
5. 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.
6. 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. 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.
7. The officials will suspend the competition at any time they deem that it is required by safety or security considerations.
8. There will be a semi-final round that most/all teams will compete in. After the semi-final round, the judges will convene and tally their scores. The judges have the discretion to select the number of teams entering the finals that they deem appropriate. Teams will be accepted into the final round in rank order from the semi-final round(s).
9. Depending on the number of contestants, in order to be considered for selection into the semi-final round, a vehicle must show that it can submerge and pass through the gate during the practice days (qualification). A vehicle that autonomously passes through the gate is guaranteed a position in the semi-final round. If this requirement is necessary, it will be announced.

10. After the competition, the judges will issue overall standings. Any team that is accepted into the final round will be ranked ahead of all teams that have not participated in the final round.
11. Each team will have 20 minutes of competition time. 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. **These times are subject to change depending on the number of contestants.**
12. **Preparation period:** The vehicle may remain on the crane, or be placed on the dock, but not in or touching the water. A team may waive any portion of the 5-minute-long preparation period and start the 15-minute-long performance period. Once the performance period starts, the team forfeits any remaining time in the preparation period.
13. **Performance period:** When the officials signal the start of the performance period, the team may ask the have their 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 the vehicle does not count against the 15-minute limit (see: **Ending a run and retrieving a vehicle**). This is to prevent unsafe actions in an attempt to speed the recovery and deployment process.
14. **Multiple runs:** A team may attempt multiple runs during the performance period. Once a team has the officials re-deploy their vehicle, all points earned in pervious runs are lost.
15. **Ending a run and retrieving a vehicle:** At any time while the vehicle is underway, the team captain can signal the end of the run and request the retrieval of the vehicle. Only officials may retrieve a vehicle and return it to the dock. The countdown clock for the performance period stops when the official touches the vehicle to recover it. The clock continues its countdown once the vehicle is safely back at the dock, or the team establishes communication with the vehicle, whichever is first (i.e. if a team has wireless communication with the sub, the countdown clock continues while the diver is returning the sub to the start).
16. Depending on the time, a team may use any of their 15-minute-long performance period time to survey the arena. The survey must be completed autonomously. Unlike performing a competition run, the clock will continue to run while retrieving a vehicle. **This is subject to change depending on the number of contestants.**
17. If a vehicle experiences 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 points 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 the competition tasks does not qualify for this option, and a vehicle interfering with those items may be disqualified at the judges' discretion.
18. The mission ends when any of the following occur:
    - The performance period time limit 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, see: **Breaching** for more details)

6.1 Onsite Expectations

1. 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 open to the public, but there is a very high possibility that a potential future employer or sponsor may also be observing the event.
2. It is expected that **ALL** teams will be present during **ALL** days of the competition. If your team does not make it into the finals, it is expected that your team will display your vehicle and be present in the team tent during this time (**ALL** teams, **All** days!)

6.2 Power

1. The United States uses a 120V 60Hz 15A electrical outlet plug. Usually 3 pins, two parallel blades (one wider than the other), and an offset semi-round pin. The wider blade is Neutral, the shorter blade is Hot/Line and the third pin is Ground.


6.3 Vehicles

1. Each team may enter one or multiple vehicles 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.
2. The judges will confer with representatives of the host facility, and any vehicle that, in the options of the judges or the representatives of the host facility, poses an unreasonable risk to the integrity of the host facility will be disqualified. The sponsors and the host organization, their employees and ages, 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 a vehicle.
3. During a qualifying, semi-final or final run, each vehicle must operate autonomously during its run. 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. When performing a qualifying, semi-final or final run, everything attached to the vehicle must

be underwater. Any part that breaks the surface is considered a breach. During practice days and practice runs, buoys may be used on the surface for communication.

4. The weight of each individual vehicle must be less than the maximum allowed. Note that bonus points are awarded to vehicles that are below a certain value, and penalties assessed for those that exceed it (Table 1). The entire vehicle must fit within the volume described in the section Weight and Size Constraints.
5. All vehicles must be battery powered. All batteries must be sealed to reduce the hazard from acid or caustic electrolytes. Batteries must not be changed inside of sealed vessels at any time. The open circuit voltage of any battery (or battery system) is a vehicle may not exceed 60 VDC. If a team has any questions or concerns, they are encouraged to contact the organizing committee.
6. No materials (except for the markers/torpedoes and compressed air) may be released by the vehicle into the waters of the arena.
7. For the safety of your team and those around you, no loaded torpedoes are allowed within the team tent. If you must test your launchers, test them either in the water, or in an open area pointing away from anyone and anything.
8. For the safety of your vehicle, we require it to be slung on a harness or sling of some type. Even if the vehicle is light enough to hand carry, we wouldn't want anyone to slip and destroy their vehicle. Also, we need to weigh the vehicle, and require that the vehicle be slung somehow for the measurement. Please see the document *Harnessing the Submarine* for hints and ideas on how to accomplish this.
9. All vehicles must bear a clearly marked kill switch that a diver can easily and readily activate. The switch must disconnect the batteries from all propulsion components and devices on the AUV. Note, this does not have to kill the computer. Upon reactivation, the vehicle must return to a safe state (props do not start spinning).
10. All props must have shrouds. The shrouds must surround the prop and have at least a 2" (5.1cm) distance between the spinning disk of the prop and the edges of the shroud (front and back). If you have a guard across the opening to prevent the insertion of a finger, this distance can be minimal. Commercial thrusters qualify as is, as long as they are shrouded.
11. A vehicle will not be allowed in the water without a properly working kill switch and prop shrouds.
12. All vehicles must be buoyant by at least one half on one percent (0.5%) of their mass when they have been shut off via the kill switch.
13. 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 vehicle to the officials in advance of the competition, with the goal of identifying potential safety concerns well in advance. When required, such technical information submitted to the judges will be held in confidence until the end of the competition.
14. Multiple vehicles are allowed in the competition. Each vehicle must include **all** the safety features mentioned above. Along with those requirements, these are specifications for multiple vehicles:

1) The total dry volume for all the vehicles must fit within the maximum volume defined in the rules. The vehicles are not required to start joined together, nor are they required to rejoin at the completion of the run.
2) From the dock, each vehicle must pass through the validation gate first before heading off for its desired task.
3) A team may elect to kill one vehicle and bring it back to the dock. If one (or more) vehicles are still out on the course, the competition time continues to count down.
4) The competition timer is only stopped when the last vehicle out on the course is returning to the dock. The timer starts again once this last vehicle is back at the dock.
5) Teams wishing to have communication between each vehicle just post their method and frequencies on the official forum by a specified date (see forum for details). Frequencies that are always off limits for inter-sub communication are the frequency range used by the pingers.

7 Sequence of Events During the Competition

7.1 Practice Runs

Practice time slots will be schedules on an ad-hoc basis by the technical director or the designee during the 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 the designee before it will be allowed into the arena.

7.2 Time Slots Announced for Competition Runs

Competition time slots will be awarded based on standing 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.

7.3 Timing for Rounds

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 the **performance time** clock. These competition minutes are for the 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.

7.4 Recovery of a Vehicle

The team captain can all for the completion of a run. The time required for retrieving the vehicle back to the dock will not count against the **performance time** limit (unless the team has a way to communicate with the vehicle during its journey back to the dock). The clock is only stopped if the vehicle has passed through the gate. The clock is not stopped if the vehicle is retrieved before passing through the gate.

7.5 Semi-final Round of the Competition

Each qualifying 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 mission will continue until the **performance time** limit has expired, or the team caption requests the end of the mission, or the judge's 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.

7.6 Final round

After the semi-final round, the judges will rank-order the teams based on their scores from the semi-final round(s), and select the top teams (as deemed by the judges) to compete in the final round. The point totals and ranking from the teams not selected are frozen. For the final round, all point totals are set to zero. The ranking of teams selected for the finals will be determined by the points their vehicle scores in the final round based on the Performance Measures alone. Any team that is selected to be in the finals will finish ahead of the remaining teams which were not selected.

8 COMPETITION TASKS

Figure 1: Aerial photo of facility. The bridge structure has no piers or supports in the pond.

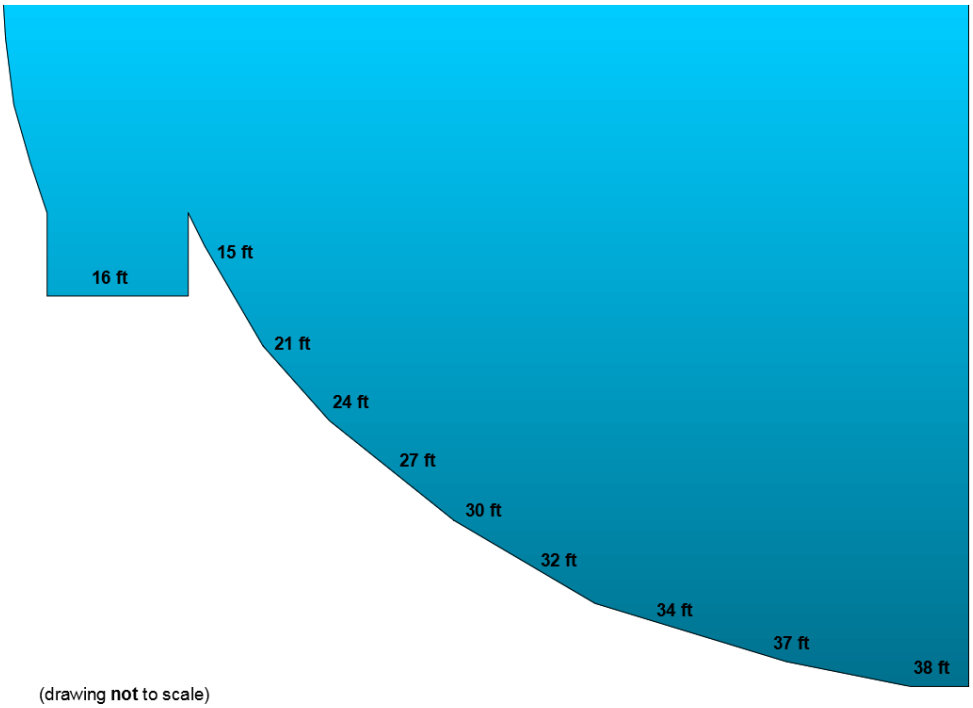


Figure 2: Cross section of facility

The launch point, gate, Path Markers, Scuttle Ship, Navigate Channel, Weigh Anchor, Set Course and Bury Treasure will be placed such that no three elements are long a line.

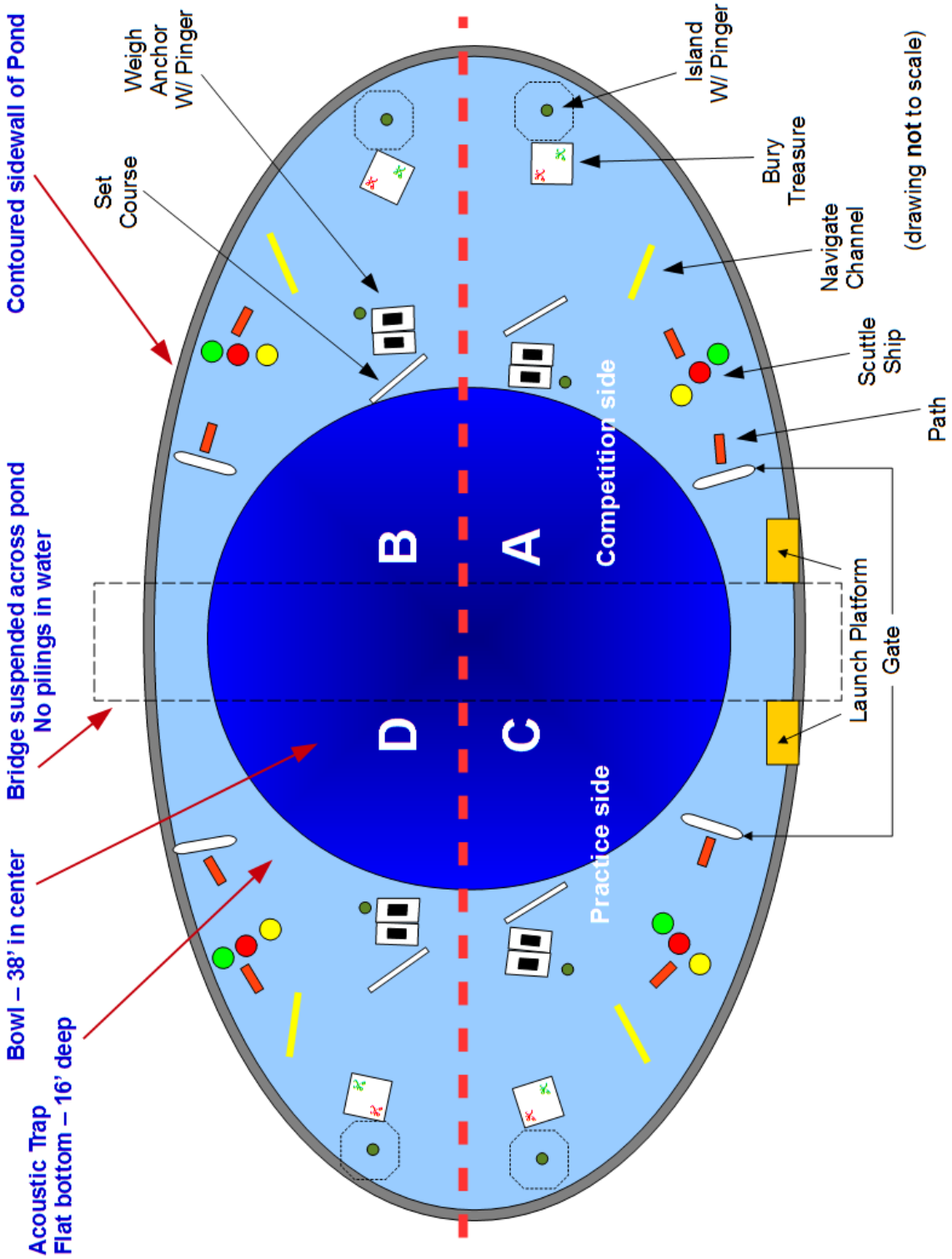


Figure 3: Course layout for Practice and Semi-finals

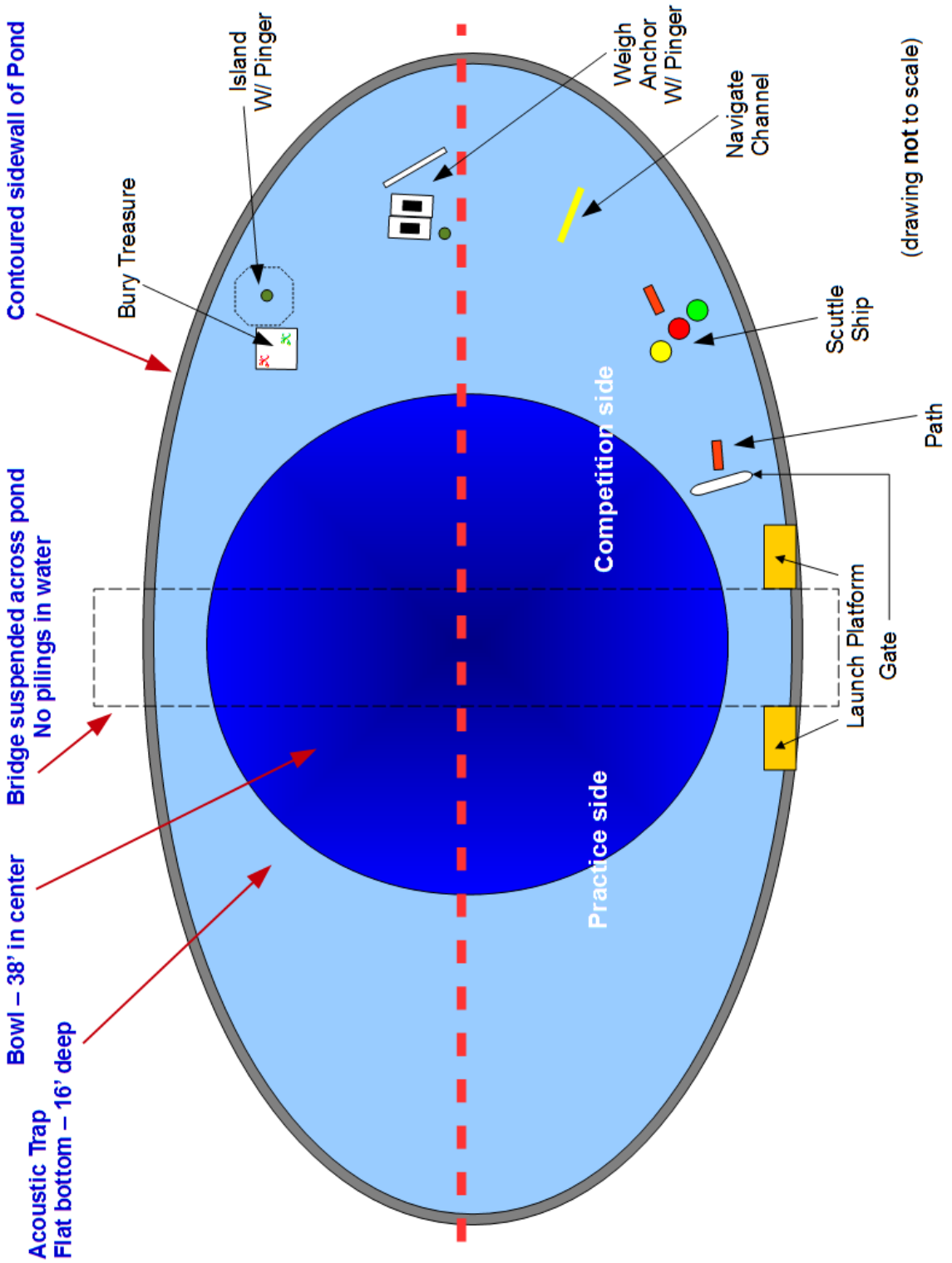


Figure 4: Course layout for Finals

8.1 Gate

The validation gate is made from 3 inch black PVC pipe. It will be buoyant, just below the surface and moored to the bottom. The vertical legs will be masked with **BLAZE ORANGE** colored Duck tape. The vehicle can pass through the gate at any depth from just below the surface to just above the floor.

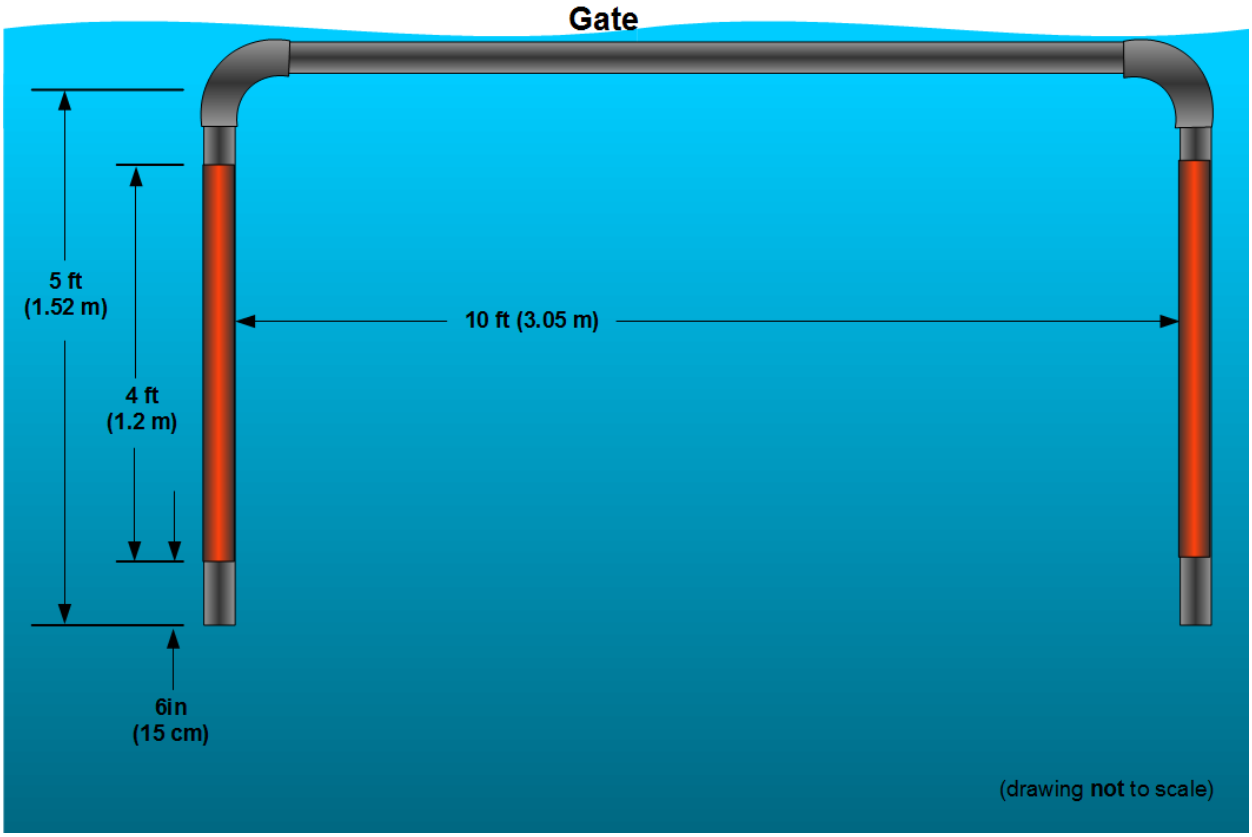


Figure 5: Validation gate.

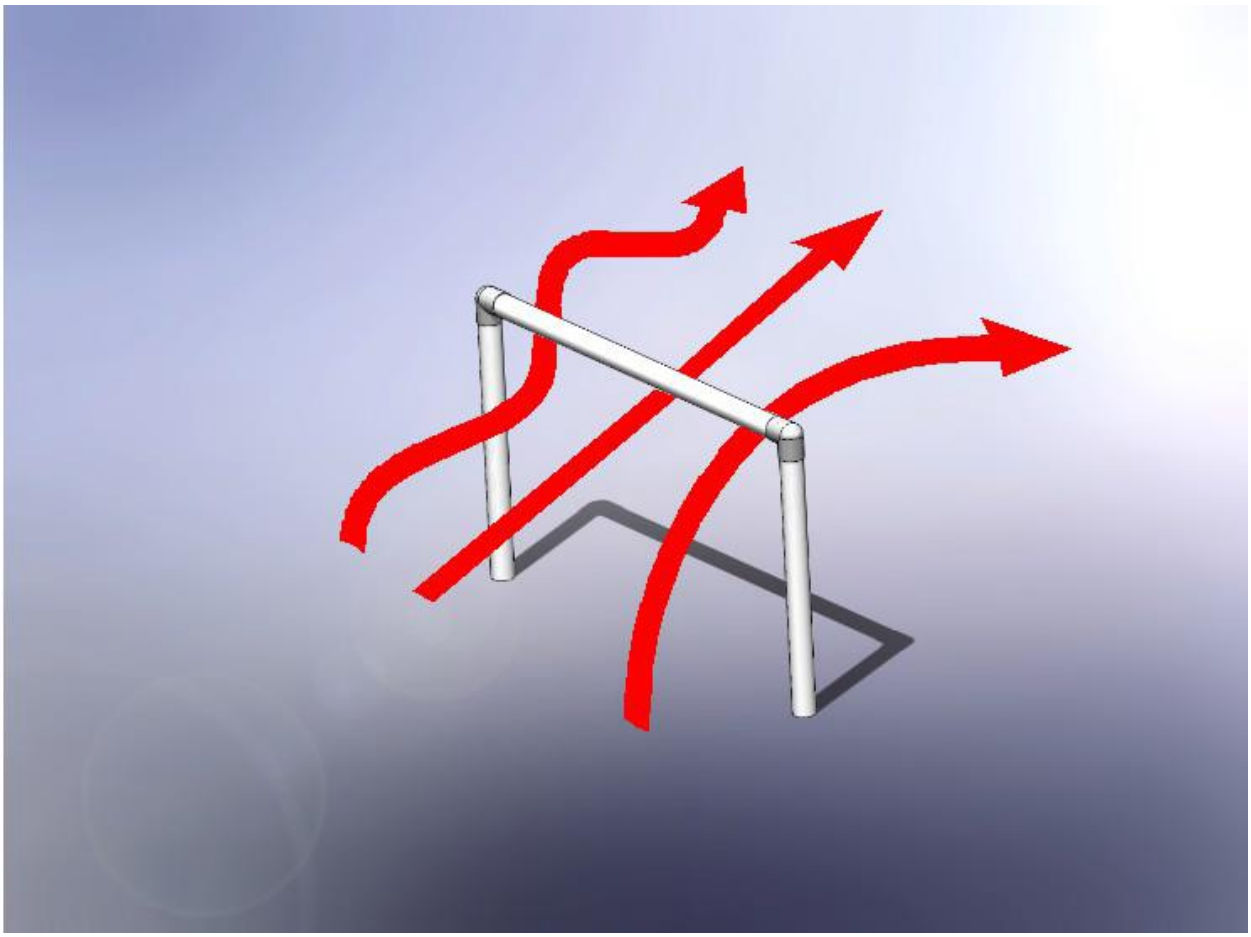


Figure 6: Valid ways to pass through the gate.

8.2 Path Marker

The path markers are 4 feet (1.2m) long by 6 inches (15cm) wide. The path will be covered in **BLAZE ORAGE** colored Duct Tape. Each path marker will be placed directly after the current task, and point to the next task. There will be one positioned at the gate that points to the Scuttle Ship (buoy) task. Positioned near the Scuttle Ship task, the next path segment will point to the Navigate Channel task. Those will be the only path segments which can be used to visually direct the vehicle.

8.3 Scuttle Ship (Buoy)

There will be two 9" (20 cm) diameter solid color Polyform A-0 buoys. One will be **Red**, the other will be **Green**. The third object will be a **YELLOW** corrugated plastic cutout buoy similar in size to the Polyform buoys (8" [20cm]). The cutout will be moored to the floor, and directly above the cutout, on the surface of the water, will be the silhouette of a ship (on corrugated plastic) which is anchored to the cutout buoy. Points are awarded for touching any buoy. Additional points are awarded for touching the **Red** then **Green** buoy. Further points are also awarded for pulling the ship on the surface underwater by moving the yellow "buoy". The ship will need to be pulled down 6" (15cm) below the surface via the **YELLOW** buoy to obtain maximum points. There will be a line on the ship silhouette that sets the pulldown depth for maximum points.

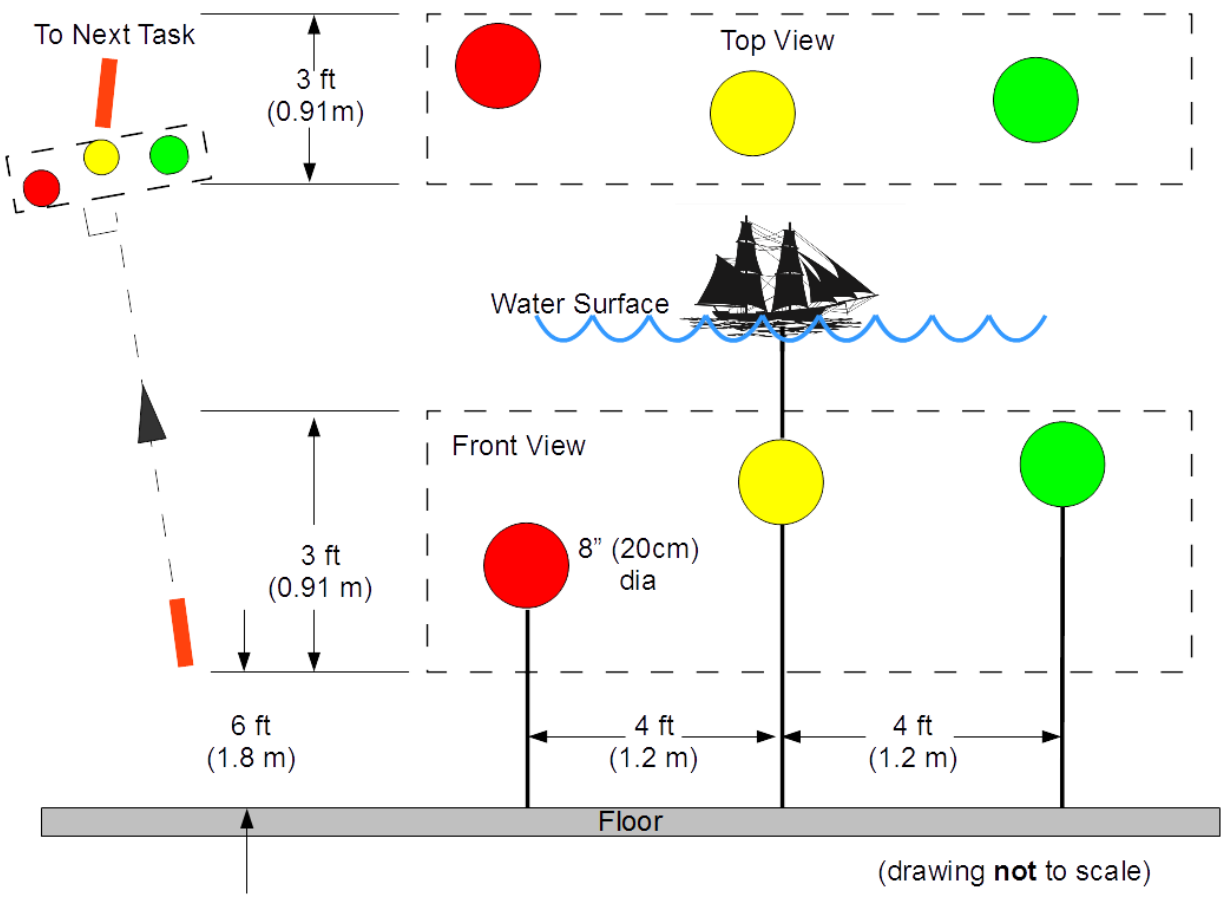


Figure 7: Scuttle Ship

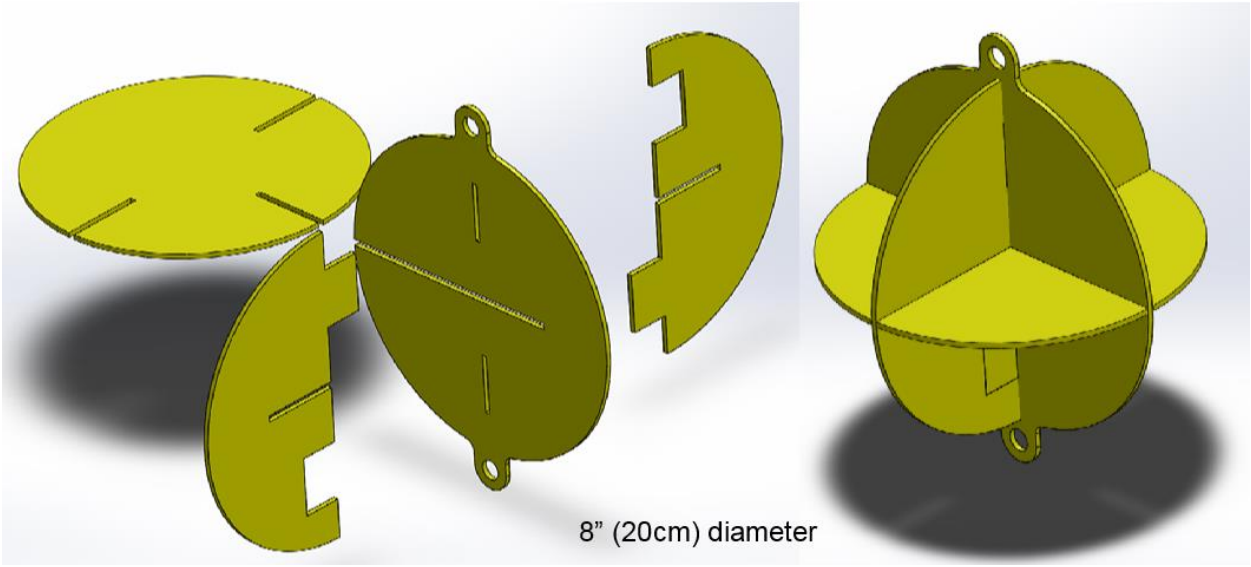
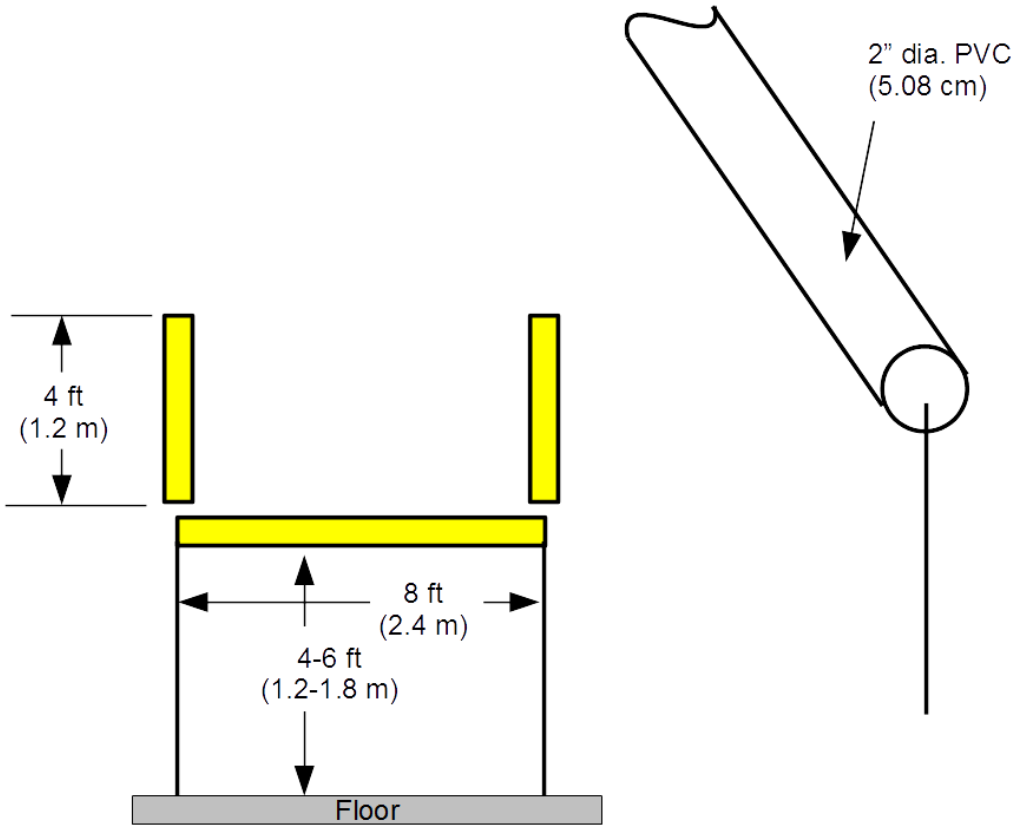


Figure 8: Yellow "buoy"

8.4 Navigate Channel

A horizontal section of 2" PVC pipe, colored with YELLOW vinyl tape, will be moored to the floor. Attached to this will be two YELLOW vertical sections. The vertical sections are tied to the horizontal PVC. Points will be awarded for passing over the obstacle. More points will be awarded for navigating with "style" (sliding sideways, backward, upside down) through the channel.



(drawing **not** to scale)

8.5 Weigh Anchor (Bins)

This tasks consists of two black bins. Each black bin will be surrounded by a 6" (15cm) white border. A total of two markers can be dropped from each vehicle. Inside each bin will be a different YELLOW anchor silhouette. One of the two bins will have a cover over the opening. The cover is ORANGE, while the handle is PURPLE. Points are awarded for dropping the markers in the open bin, or on the outer white edge. To obtain maximum points, the vehicle must remove the cover and drop both markers in the bin that was once covered.

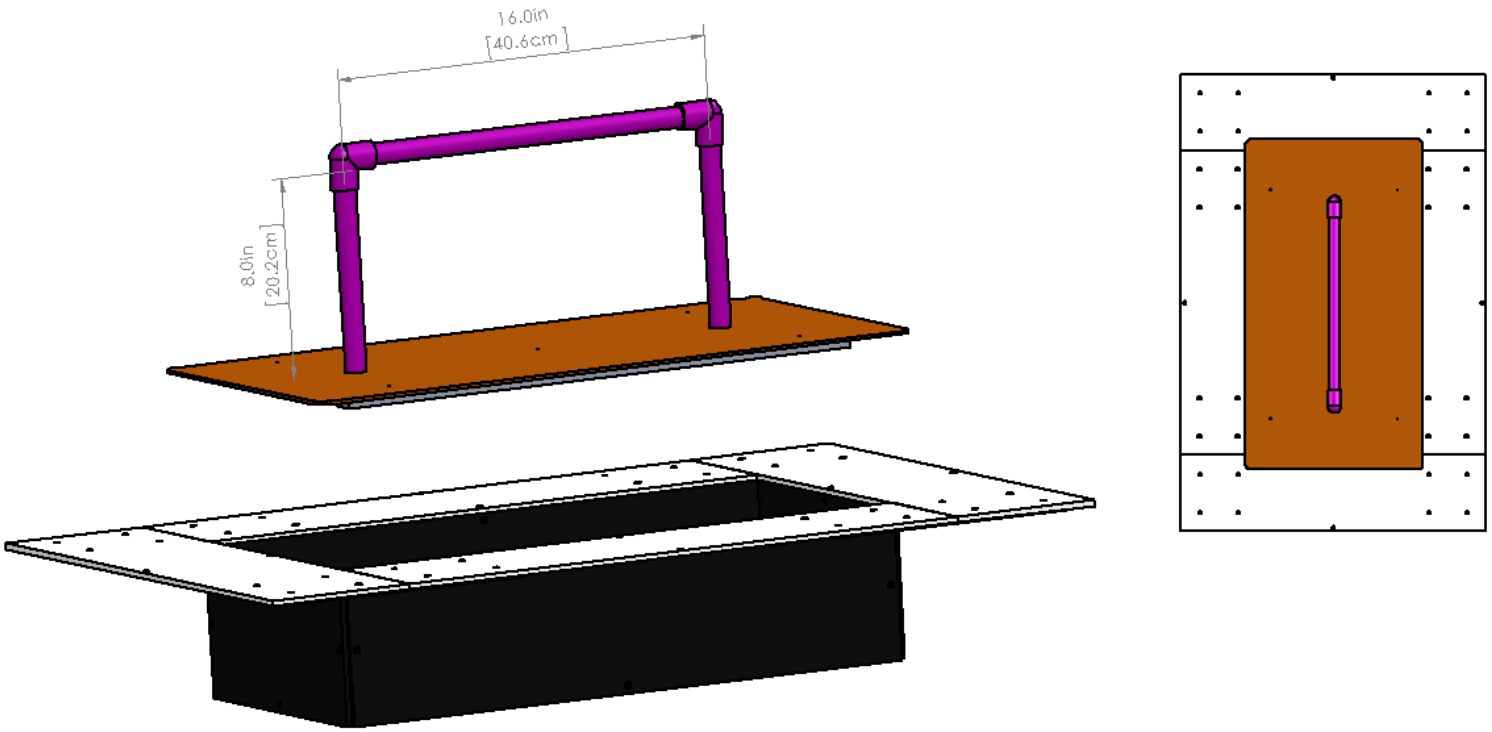


Figure 9: Bin with cover.

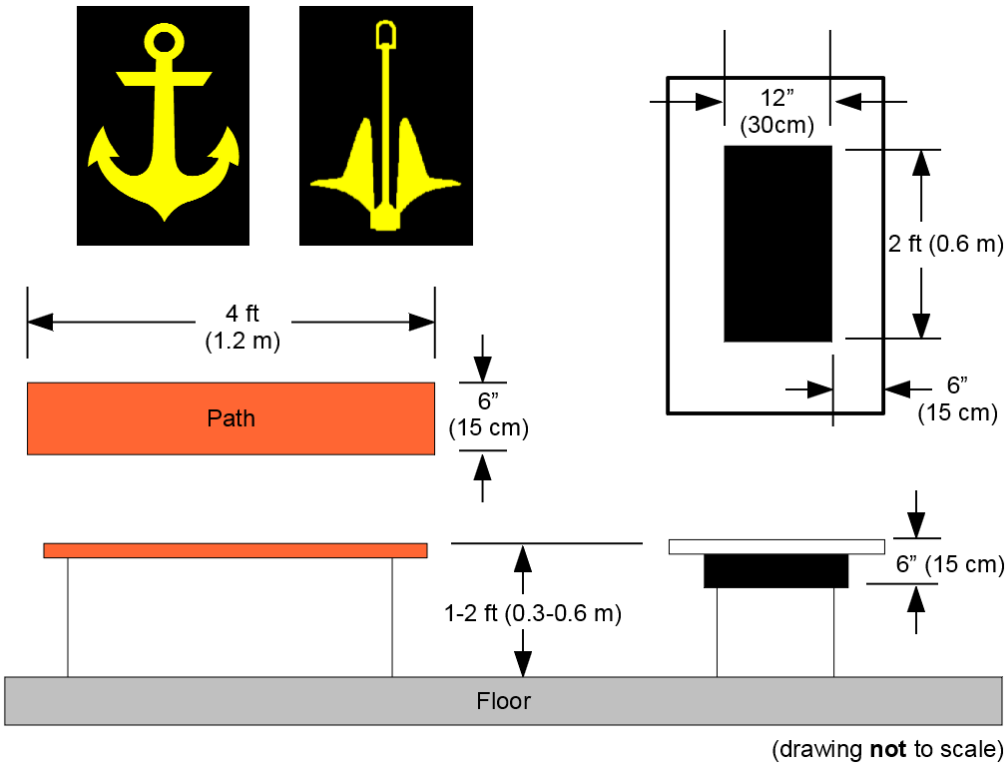


Figure 10: Path marker, bin and anchor silhouettes.

8.6 Set Course

There is a pinger which can be used to guide the vehicle to this task. There will be a large vertical YELLOW square moored to the floor with two different size square openings. Two small openings and two large openings. There will be a 1" (2.5cm) **RED** border around the openings. A total of two torpedoes can be fired from the vehicle. On the face of the square will be a compass rose, with the cardinal directions (**N**, **S**, **E**, **W**). Above each opening will be one of the cardinal direction. There are four possible combinations for the openings: **NE**, **NW**, **SE**, **SW**. One of the two small squares will be covered. The cover is **ORANGE**, while the handle is **PURPLE.** The ship's course will be assigned at the beginning of the day (for example, **NW**). Each small opening and large opening will have each half of the cardinal direction. Points will be awarded for firing the torpedo through any of the openings. More points will be awarded for firing torpedoes in the correct course heading (**N** or **S** followed by **E** or **W**, for example **N** then **W**). Maximum points will be awarded for removing the cover, and firing torpedoes through the small openings in the correct order.

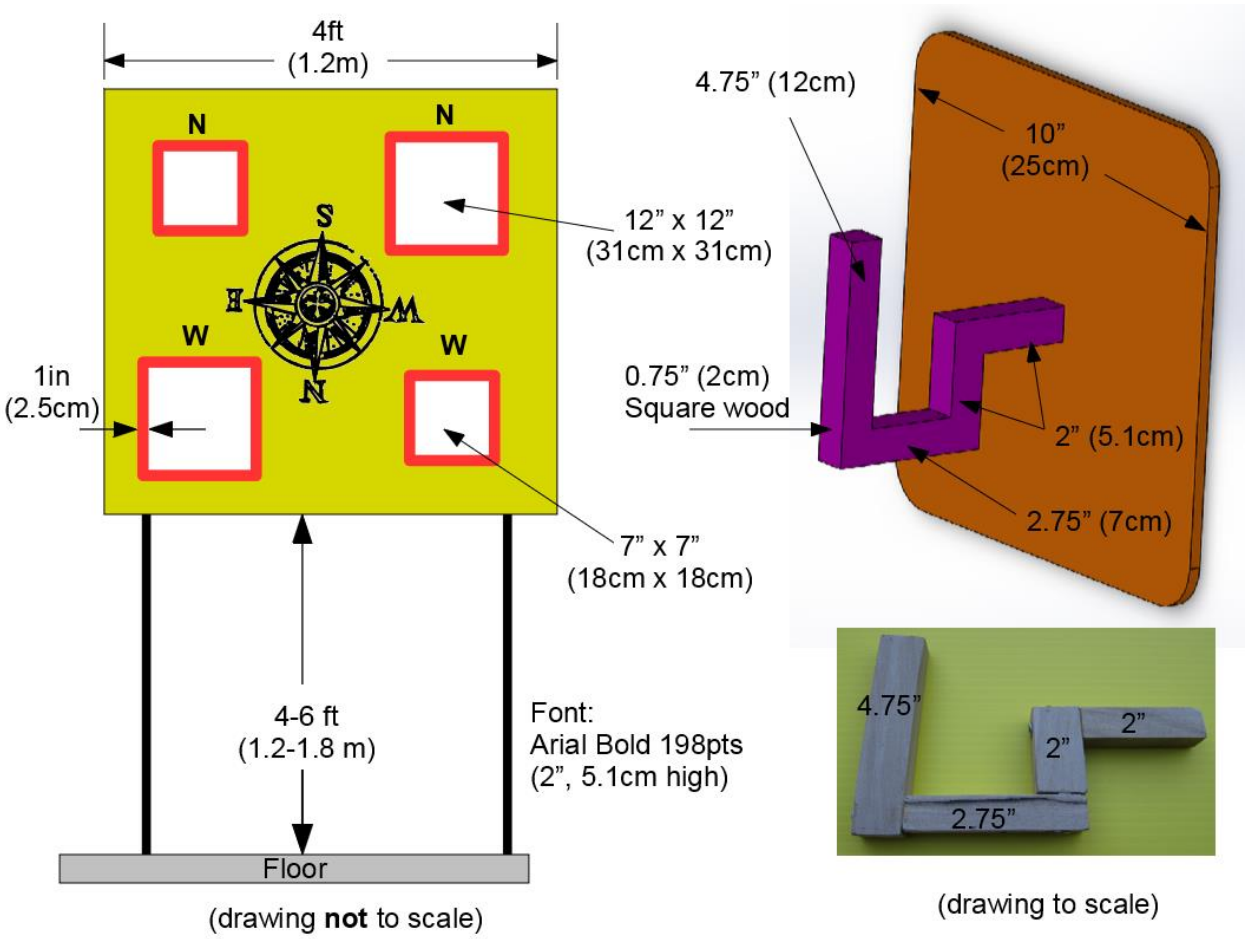


Figure 11: Set course with cover.

8.7 Bury Treasure

This task consists of an acoustic pinger located off the floor of the pool. The pingers in each section will be assigned a different frequency (***Still working on the timing). Consequently, the pinger for Weigh Anchor and Bury Treasure in each quadrant will have the same frequency, and only one of these from each quadrant will be on (either Weigh Anchor or Bury Treasure). Placed directly above the pinger, on a tower, are two stacks each of coins (4 total), one set colored **RED** and one set colored **GREEN**. Floating above the pinger on the surface is an octagon representing the Island. In order to obtain full points for the octagon, the vehicle must surface completely inside the octagon.

Positioned next to the pinger/tower is the location on the island to bury the treasure (large flat horizontal surface "table"). The table will be ~1ft (0.3m) off the floor. On the "table" there will be two "**X**"s ('cause X marks the spot!). One X is **RED** and one X is **GREEN**. Points are awarded for picking up an object, surfacing with an object and placing it on the "table". Maximum points are awarded for placing each of the colored objects near it's associated colored "**X**".

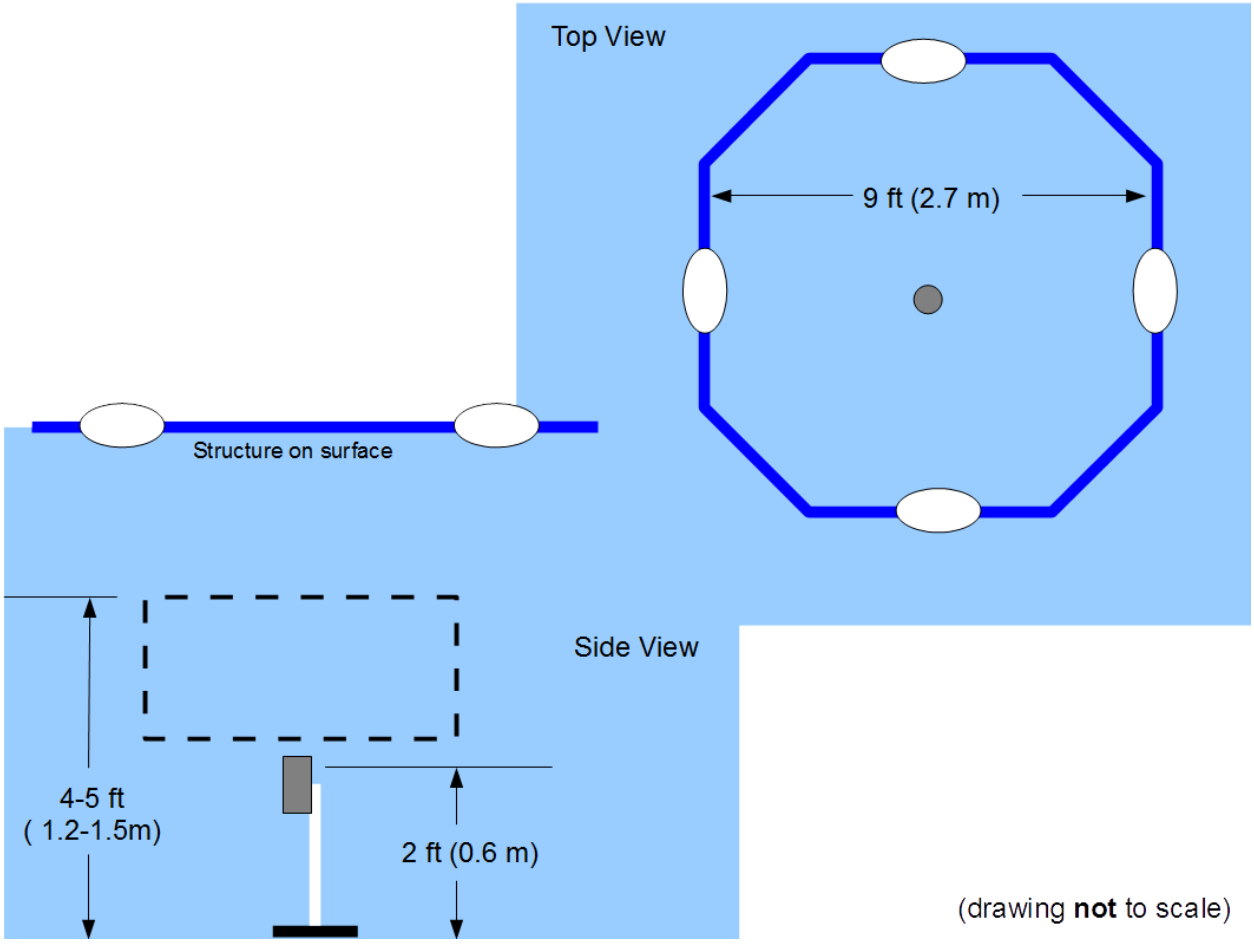


Figure 12: Bury treasure

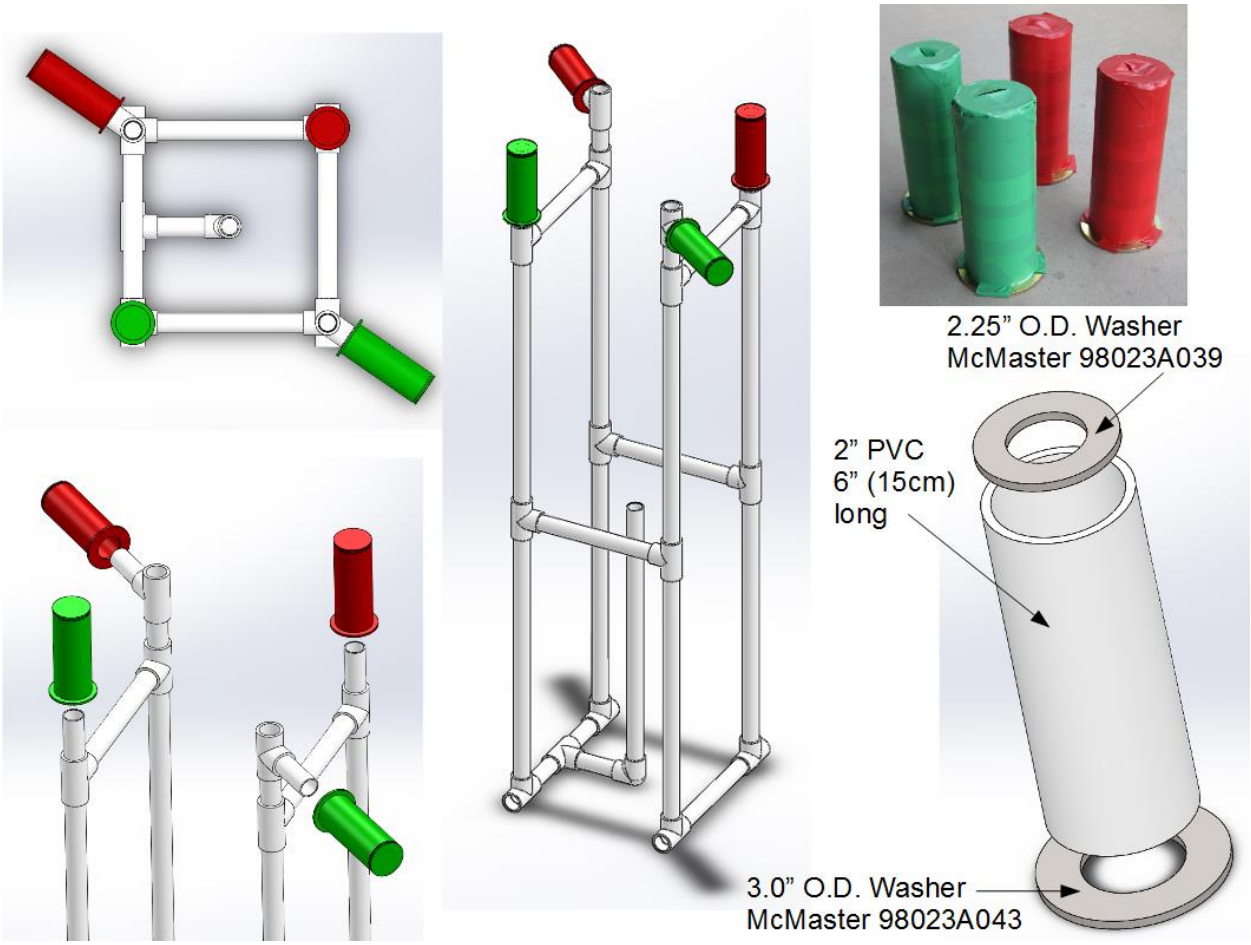


Figure 13: Tower holding the coin stacks

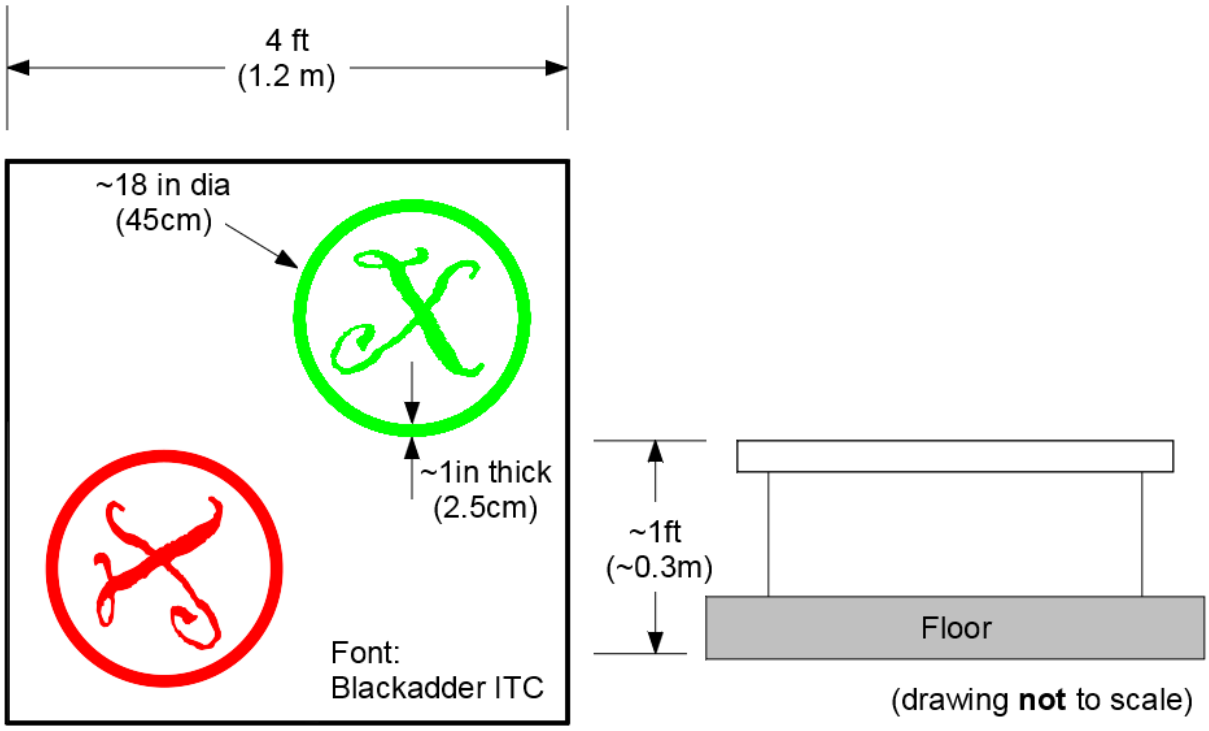


Figure 14: Island location to bury treasure.

9 SCORING

Each of the tasks has a point value associated with it. The tasks can be completed in any order. The recovered object must be attached to the vehicle when the vehicle is on the surface to obtain maximum points for "surfacing with object".

The team captain may stop the run at any time and keep the accumulated points. The team may decide to start another run, in an attempt to accomplish more/different tasks. At the start of a new run, the points accumulated from the previous run are forfeit. The only points which are recorded are from the very last run.

NEW! Weigh Anchor / Set Course and Bury Treasure will *only* be marked with a pinger. There will be no path markers that point to either task. A team may request that a specific pinger be switched on (pinger near the Weigh Anchor / Set Course, or pinger near the Bury Treasure). However, additional points will be awarded if the team requests a random pinger.

At the start of a run, a team may request a random pinger selection. Once set, the random pinger cannot be changed. If the vehicle obtains any points from the task(s) associated with the random pinger, bonus points are awarded. At any point after the vehicle has obtained points from the task(s) associated with the random pinger, the team may request to switch the pinger. No addition random points can be obtained at the second task. If the team captain requests to

switch the pinger before the vehicle has acquired any points, the run reverts back to a specific pinger request run, and no random pinger points can be achieved.

9.1 Time

Each vehicle is expected to have 15 minutes to complete the entire mission (with an additional 5 minutes of dock preparation time). Any vehicle that touches a buoy, passes over the obstacle, places at least one marker in the bin or on the lip (or fires a least one torpedo through the opening) and surfaces within the octagon will receive bonus points proportional to the unused time. Each vehicle must begin the run by passing under a validation gate. At any time during the run, if a vehicle breaches the surface, the run is terminated (See the section "Breaching" for the exception, *'cause there's always one*).

9.2 Breaching

When completing the sequence of tasks, a team may choose to complete the surfacing task out of order (surface within the octagon). In this case (and only this case) a vehicle may breach the surface and then submerge again to complete the remaining tasks without risking disqualification. For a vehicle to continue after breaching, it must surface inside of, or touching the octagon. A breach outside of the octagon will end the run.

9.3 Interference

Vehicles that interfere with competition elements may be disqualified at the judges' discretion. "Interference" does not include cases where, in the opinion of the judges, a vehicle is attempting to complete one of the tasks. If a vehicle becomes entangled on a competition element the run will be declared complete. Teams may keep the points earned on that run, or may have the vehicle returned to the launching platform and start another new run. If a new run is begun, all points from the previous run are forfeit.

9.4 Point Breakdown

Subjective Measures	Maximum Points
Utility of team website	50
Technical Merit (from journal paper)	50
Written Style (from journal paper)	50
Technical Accomplishments (from static judging)	75
Craftsmanship (from static judging)	75
Team Uniform (from static judging)	10
Team Video	50
Discretionary static points (awarded after static judging)	40
Total	400

Performance Measure	Maximum Points
Weight	See Table 1 / Vehicle
Marker/Torpedo exceeding weight or dimensional specifications by <10%	-500/maker
Pass through the Validation Gate	100
Maintain a fixed heading through gate	150
Follow the "Path"	100 / segment
Scuttle Ship (Buoy: Any, Red than Green)	400, 800
Scuttle Ship (Buoy: Yellow, pull down)	600
Navigate Channel (>1/2 above, <1/2 below) Straight through // w/ Style	400, 600 // +100 / style points (max of 8x)
Weigh Anchor: remove cover	500
Weigh Anchor: uncovered/covered	600, 1200 / marker
Set Course: remove cover	500
Set Course: any, correct lg, correct sm	500, 1000, 1500 / torpedo
Surface within the Octagon	1000
Surface with the object	500 / object
Drop the object	200 / object
Object on Island (Table)	500 / object
Correct color stack on "X" (Table)	1000 / object
Random Pinger selection	2000
Finish the mission with T minutes (whole + factional)	Tx100

9.4.1 Subjective Measures description

Technical accomplishments 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 works, if you use a well-built, well-designed off-the-shelf component, your team does not get points for the

component's good technical design. You will get points for selecting a component that is, in the opinion of the judges, well suited to the engineering needs of the vehicle.

9.4.2 Performance Measures description

Passing through the validation gate: The judges' discretion will demine whether or not the vehicle satisfactorily passes through the validation gate.

Maintain a fixed heading through the gate: Did the sub travel in a "straight line" through the validation gate? This is intended to separate a vehicle that is maintaining a heading, or otherwise accomplishing something autonomously verses a vehicle that is initially pointed at an angle to compensate for the vehicle's uncompensated yaw drift. For example, a vehicle that has a slight sinusoidal motion due to PID tuning, but on average is maintaining a heading has traveled straight through the gate. Or a vehicle that is searching for the gate, finds it and heads through it has traveled straight through the gate. A vehicle that is pointed away from the gate to compensate for un-tuned motors and yaw drift has not traveled straight through the gate.

Follow the "Path": How well did the vehicle find and follow the segment?

Scuttle Ship (Buoy): Partial points are awarded if you track the buoy(s) but you brush by instead of a deliberate bump. Full points to touching the Red then Green buoy without touching the Yellow in-between. Full points for pulling the surface ship downward 6" (15cm) via the yellow buoy, partial points are awarded for not fulling pulling the ship down. Manipulation of only the rope holding the buoys/ship will not count for points.

Navigate Channel: Did the vehicle pass over the PVC without touching it? What percentage of the vehicle passed over the top of the object?

"Style" is broken into 90° increments. For every 90° change in orientation, a bonus is added. The channel starts ~10 ft (3m) before the PVC structure and continues ~10 ft (3m) after the structure. For example:

- If a vehicle changes it's heading by 90°, and passes through the structure, then 1*(bonus points) are added to the base score.
- If a vehicle passed through the structure backwards (180° change), then 2*(bonus points) are added to the base score.
- If a vehicle is able to complete a full barrel role (360° rotation), then 4*(bonus points) are added to the base score (and 8* for a 720°!).

Weigh Anchor: The covered bin is worth more points than the uncovered bin. Two markers in any bin will count twice. Partial points may be awarded if the marker lands near or on the lip of the bin.

Set Course: A torpedo must pass through the opening for full points. The correct sequence is either when the first torpedo passes through the opening for the first part of the sequence, or the second torpedo passes through the opening for the second part of the sequence. Partial points may be awarded if the torpedo passes close to the opening.

Surface within the Octagon: The sub must fully surface within the octagon to obtain full point value. Partial points will be awarded based on how much the sub is outside the octagon.

Grabbing the Object: The structure must be captured and constrained by the vehicle to obtain full points. Partial points may be awarded for a partial capture.

Releasing the Object: The structure must fall free from the vehicle to obtain full points. A structure hanging on the vehicle may be awarded partial points with judges' discretion.

Object on Island: The object must remain on the Island (table) to obtain full points. Partial points may be awarded if the objects lands near or falls off the island.

Object near X: The object must be completely with the correct color circle to obtain full points. Partial points will be awarded based on how much the object is outside the circle.

Time Bonus: At a minimum, a sub must touch a buoy, pass over the Navigate Channel task, drop at least one marker in the bin (or fire one torpedo though the cutout), and fully surface within the octagon to obtain a time bonus. These tasks can be completed in any order.

The time bonus is calculation of whole minutes remaining plus fractional seconds. For example, with a remaining time of 7:13, a team will receive (7+13/60)*100=721.667 points (approximately).