



22nd Annual International RoboSub Competition

Mission and Scoring

TRANSDEC-vania

Version 2, June 30, 2019

Naval Information Warfare Center Pacific (NIWC PAC)
TRANSDEC

San Diego, California, USA

July 29 – August 4, 2019



RoboSub Mission and Scoring

*2019 RoboSub**www.robosub.org*

1 Official RoboSub Competition Website

The official competition website is www.robosub.org. The documents posted at www.robosub.org are the official documents for this competition. All documents referenced here and in other RoboSub documents are available at the official competition website. These documents are updated regularly. It is the Teams' responsibility to check the website for the most recent revisions.

2 Competition Points of Contact

Please direct your comments and questions to the [RoboSub Forum](#). Teams are encouraged to participate in the community.

- Technical Director – David Novick: dnovick@robonation.org
- Competition Questions: competitions@robonation.org
(questions related to registration, travel, hotel or team deliverables)

3 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.

4 Theme

Vampire: Nosferatu was released in Germany in 1922. It was an unauthorized adaption of Bram Stoker's *Dracula* (1897). *Dracula* is one of many regional lore written surrounding vampires. The Romanian **Count Dracula** (based on a Wallachian Prince named Vlad Tepes), can turn into other creatures such as a bat or wolf. They are repelled by sunlight, crucifixes and garlic. They can be killed by a wooden stake through the heart and beheading. In China, a **Jiangshi** (hopping vampire) is a deceased loved one who is brought back home by a sorcerer. The **Draugr** is an Icelandic parasitic ghost who roams the earth and harasses the living to drive them mad or even kill them. In India, the **Vetalas** are undead ghoulish beings that inhabit corpses, hang upside down on trees, found on cremation ground and cemeteries. The **Aswang**, from the Philippines, Malaysia, Cambodia and Indonesia, take the form of an attractive girl by day, and develops wings and a long, hollow, thread-like tongue by night.

5 Mission

The fundamental goal of the mission is for an AUV to demonstrate its autonomy by interacting with various vampires. Orange guide markers will help direct the vehicle to the beginning tasks. Two pingers will guide the AUV to the remaining two tasks. Along the way, there will be garlic and crucifixes the vehicle can pick up to be used in other locations. The vehicle will have these tasks:

- *Enter the Undead Realm* (Gate)
- *Slay Vampires* (Touch buoys)
- *Drop Garlic* (Drop markers)
- *Stake Through Heart* (Manipulation/torpedoes)
- *Expose to Sunlight* (Retrieve object(s), surface, move/release objects(s)).

6 Competition Overview

6.1 Venue

The competition will be held at the NIWC PAC TRANSDEC facility. The large facility allows us to divide the area into four sections and run full missions in every section. The mission will take place in 16ft (4.9m) of water. 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 course will be expanded to include both sections of the competition side.

6.2 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 ≤ 22kg)	Bonus of $80 + (48.5 - lb)$ $80 + 2.2*(22 - kg)$	N/A

6.3 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 vehicle may carry up to two markers. A reasonable amount of time will be spent looking for lost markers, however consider them expendable and have backups.

6.4 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 underwater from close range. A vehicle may carry up to two torpedoes

6.5 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) and will be set to the maximum power. The pingers in each section will use the same frequency. For example, the two pingers in section A will both have the same frequency, and the two pingers in section B will both have the same frequency (but different from section A). There will be four different frequencies used, one for each section, and only one pinger in each section will be active at a time. The ping for each section will be deconflicted with the pings in other sections such that only one pinger will ping at a time, see Figure 1. As shown in

Figure 6, the frequencies for the sections will be: A – 30kHz, B – 40kHz, C – 25kHz, D – 35kHz.

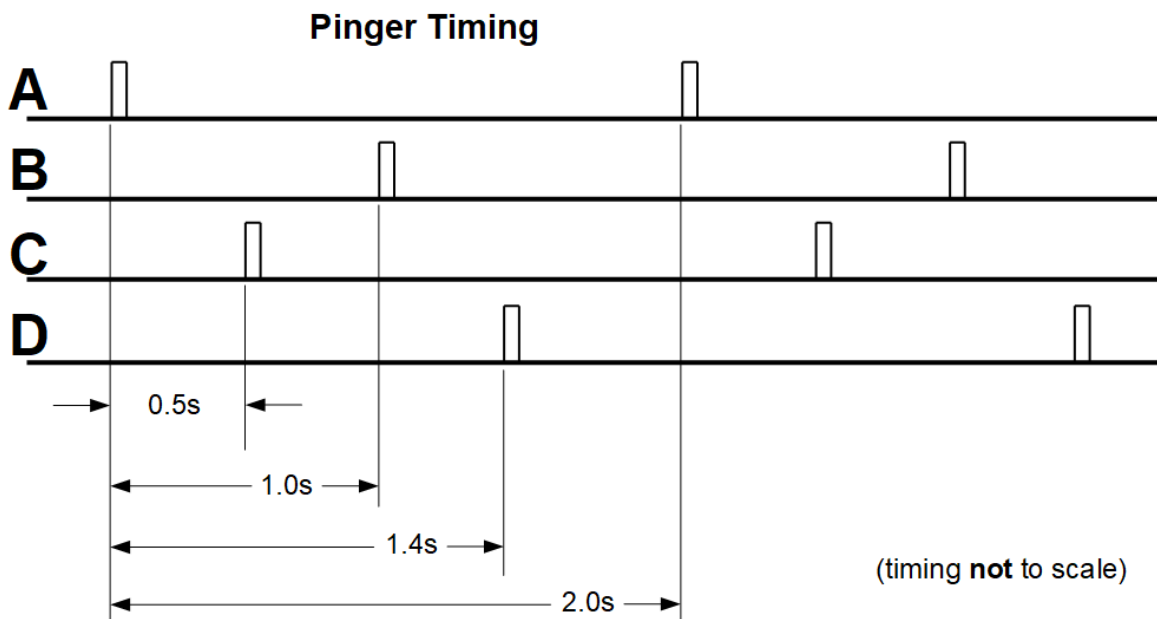


Figure 1: Pinger timer for the four sections.

7 Competition Rules

- Rule 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.
- Rule 2 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.
- Rule 3 Only the student component of each team is eligible for the cash awards.
- Rule 4 One student member of the team must be designated as the "team lead". The team lead, and only the team lead, will speak for the team during the competition run.
- Rule 5 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.
- Rule 6 The officials will suspend the competition at any time they deem that it is required for safety or security considerations.
- Rule 7 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. Teams will be accepted into the final round in rank order from the semi-final round(s).
- Rule 8 Every vehicle from each team must qualify to compete. During the practice days, a vehicle that autonomously passes through the gate is guaranteed a position in the semi-final round.

- Rule 9 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.
- Rule 10 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.
- Rule 11 Preparation period: The vehicle must remain near the staging area (the location where the vehicle is attached to the crane). 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.
- Rule 12 Performance period: When the officials signal the start of the performance period, the team may ask to 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 (to the dock, or on the crane) 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.
- Rule 13 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 previous runs are lost.
- Rule 14 Ending a run and retrieving a vehicle: At any time while the vehicle is underway, the team lead 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).
- Rule 15 After a run, a team may lock in their current score and use any remaining 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 timing and the number of contestants.

Rule 16 If a vehicle experiences significant interference from a piece of equipment, line, cable or diver deployed in support of the competition, the team lead 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 lead 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.

Rule 17 The mission ends when any of the following occurs:

- The performance period time limit ends.
- The judges' order the end of the mission.
- The team lead requests the end of the mission.
- The vehicle breaches the surface outside the surface marked area (as determined by the judges, see: Breaching for more details)

7.1 Onsite Expectations

7.1.1 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.

7.1.2 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, ALL open hours!)

7.2 Power

7.2.1 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.



Figure 2: US electrical outlets

7.3 Vehicles

- 7.3.1 Each team may enter one or multiple vehicles into the competition. Each vehicle will be physically inspected by the competition technical staff. The technical staff may disqualify any vehicle that they deem to pose an unreasonable safety hazard to the host facility. The sponsors 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 to or by any vehicle.
- 7.3.2 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 submerged with the vehicle. 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.
- 7.3.3 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.
- 7.3.4 All vehicles must be battery powered. All batteries must be sealed to reduce the hazard from acid or caustic electrolytes. Batteries must not be charged inside of sealed vessels at any time. The open circuit voltage of any battery (or battery system) in a vehicle may not exceed 60 VDC. If a team has any questions or concerns, they are encouraged to contact the Technical Director.
- 7.3.5 No materials (except for the markers/torpedoes and compressed air) may be released by the vehicle into the waters of the arena.
- 7.3.6 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 everyone and everything.
- 7.3.7 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.
- 7.3.8 All vehicles must contain 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).

- 7.3.9 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.
- 7.3.10 A vehicle will not be allowed in the water without a properly working kill switch and prop shrouds.
- 7.3.11 All vehicles must be positively buoyant by at least one half of one percent (0.5%) of their mass when they have been shut off via the kill switch.
- 7.3.12 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.
- 7.3.13 Multiple vehicles (two total) are allowed in the competition. Each vehicle must include all the safety features mentioned above. Along with the above requirements, these are specifications for multiple vehicles:
- 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.
 - Each vehicle will be weighed, and the bonuses/penalties will be calculated on a per vehicle basis.
 - From the dock, each vehicle must pass through the validation gate first before heading off for its desired task.
 - 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 (think of them as a swarm). Any vehicle that has been killed or has breached will be returned to the dock and can be redeployed at any time.
 - The competition timer is only stopped when the last vehicle out on the course is under diver control and returning to the dock. The timer starts again once this last vehicle has returned to the dock, or the first vehicle leaves the dock (starting its new run).
 - Teams wishing to have communication between each vehicle must post their method and frequencies on the official forum by a specified date (see forum for details). Acoustic frequencies that are always off limits for inter-sub communication are the frequency range used by the pingers.
 - Inter-vehicle communication and cueing of one vehicle by another is an advanced behavior that merits special points. If such behavior is executed, teams are encouraged to present post-run supporting documentation (e.g., vehicle logs) to the judges.

7.4 Scoring

- 7.4.1 There is a 10ft (3m) radius imaginary buffer (spherical) around each task. When a vehicle enters the buffer, an attempt for that task has started. When a vehicle exits the buffer the attempt for that task has ended.
- 7.4.2 If multiple tasks are grouped such that there isn't the required separation, the attempt on the first task has ended when the vehicle has clearly moved on to the next task.
- 7.4.3 If a task is a single event (pass through the gate, touch buoys, etc.), points for a task are awarded on a per attempt bases.
- 7.4.4 If a task can collect items (i.e. it has a bin), points are added until the maximum points are reached. I.e. If there is a maximum of two markers in a bin, one vehicle drops 1 marker in the bin, and a second vehicle drops 2 markers in the bin, the points are capped at 2 markers in the bin.
- 7.4.5 The higher value for a task during a run replaces the previous score. If a vehicle revisits a task in the same run, the higher score is used.
- 7.4.6 Semi-finals: Each vehicle is scored independently, the run starts when the vehicle leaves the starting location and ends when the team lead calls to kill that vehicle, the vehicle breaches, or the time runs out. The scores are based on the last run of each vehicle.
- 7.4.7 Finals: The "Best of" run for each vehicle is used to determine the final score.

8 Sequence of Events During the Competition

8.1 Vehicle Pre-qualification

Before the start of the competition, teams may elect to pre-qualify their vehicle. The vehicle that is used to pre-qualify must also be the vehicle that will be entered into the competition. A team that successfully completes the pre-qualification will not be required to qualify on-site during the practice days of the competition (see **Qualification Runs** below).

The pre-qualification course consists of two pieces: a horizontal **Gate** and a vertical **Marker** (see [Figure 3](#)). The **Gate** is 6.6 ft (2m) in length and is positioned 3.3 ft (1m) below the surface of the water. The **Gate** can be any diameter and any color the team chooses. The **Gate** can be anchored to the floor by any means necessary (using PVC elbows to create two vertical legs, line on each end to moor the **Gate** to the floor, etc.). The vertical **Marker** can be any diameter and any color the team chooses. It will be positioned 33 ft (10m) beyond the **Gate** and must touch the floor and break the surface of the water.

The pre-qualification maneuver consists of starting the vehicle 9.8 ft (3m) behind the **Gate**. It must be a fully autonomous run, and everything attached to the vehicle must submerge with the vehicle (nothing floating on the surface). The vehicle must, autonomously, pass through the **Gate**, circle around the **Marker** and pass back through the gate.

The team must record the entire run from start to finish with no breaks in the video. This will be submitted to Competition technical staff for evaluation. The team will be told if they have successfully pre-qualified. If a team does not pre-qualify, they will be told the reason why, and they may submit another video as long as the deadline for the submission has not expired.

8.2 Practice Runs

Practice time slots will be scheduled 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 in the arena. Each vehicle must be approved by the technical director or the designee before it will be allowed into the arena.

8.3 Qualification Runs

When necessary (greater than 24 teams registered), teams will be required to complete a qualification run. Anytime during a team's practice run (during the practice days), a team may request that their run be observed as a qualification run. The vehicle must pass through the gate autonomously (with everything attached to the vehicle submerging with the vehicle in order to qualify. Qualification awards the team with two (2) time slots during the semi-finals days (one on the first day and one on the second day). For any team that has not qualified during the practice days, wild card slots will be held open during the semi-finals days. They must first qualify (pass through the gate) before they are able to choose

the next available wild card slot. Only one slot per day can be used by a non-qualifying team.

Teams can pre-qualify by submitting a pre-competition video demonstrating prescribed maneuvering competency. No need to wait for on-site practice time.

8.4 Time Slots Announced for Competition Runs

Competition time slots will be awarded based on standings from 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.

8.5 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.

8.6 Recovery of a Vehicle

The team lead can call for the end 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.

8.7 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 lead 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.

8.8 Final round

After the semi-final round, the judges will rank-order the teams based on their scores from the semi-final rounds and select the top teams to compete in the final round. The point totals and ranking from the teams not selected for the finals 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(s) scores during their run in the finals and is based only on the Performance Measures. Regardless of the points earned during the finals, any

team that is selected to be in the finals will finish ahead of the remaining teams which were not selected.

9 Competition Tasks

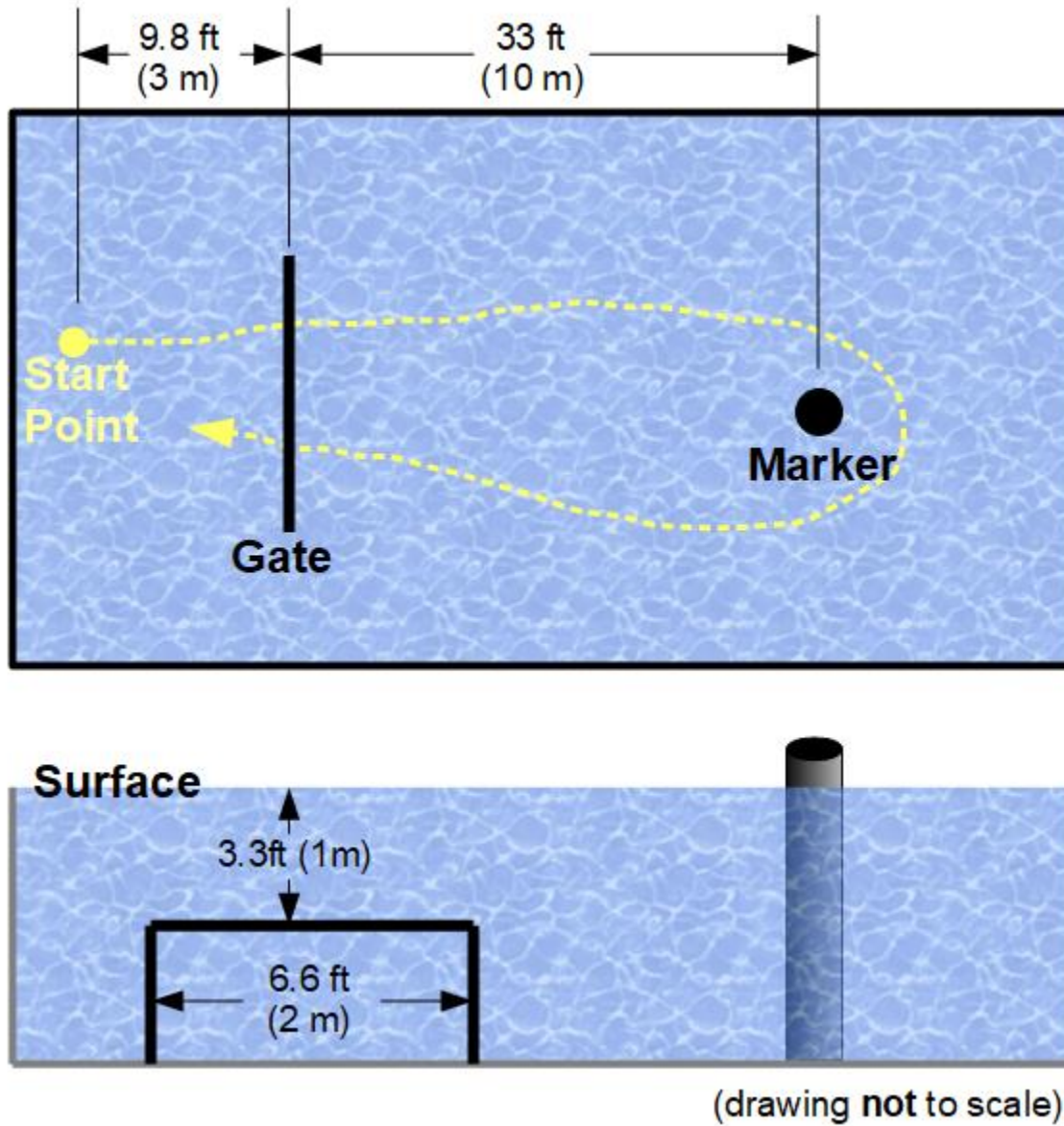


Figure 3: Pre-qualification



Figure 4: Aerial photo of facility. The bridge structure has no piers or supports in the pond.

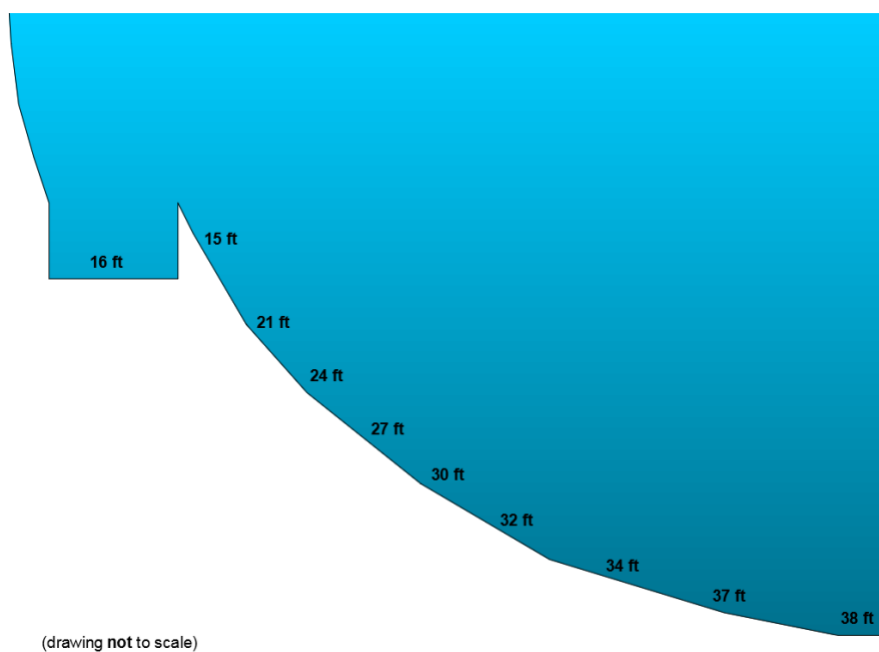


Figure 5: Cross section of facility

The launch point, gate, or any of the tasks will be placed such that no three elements are along a line.

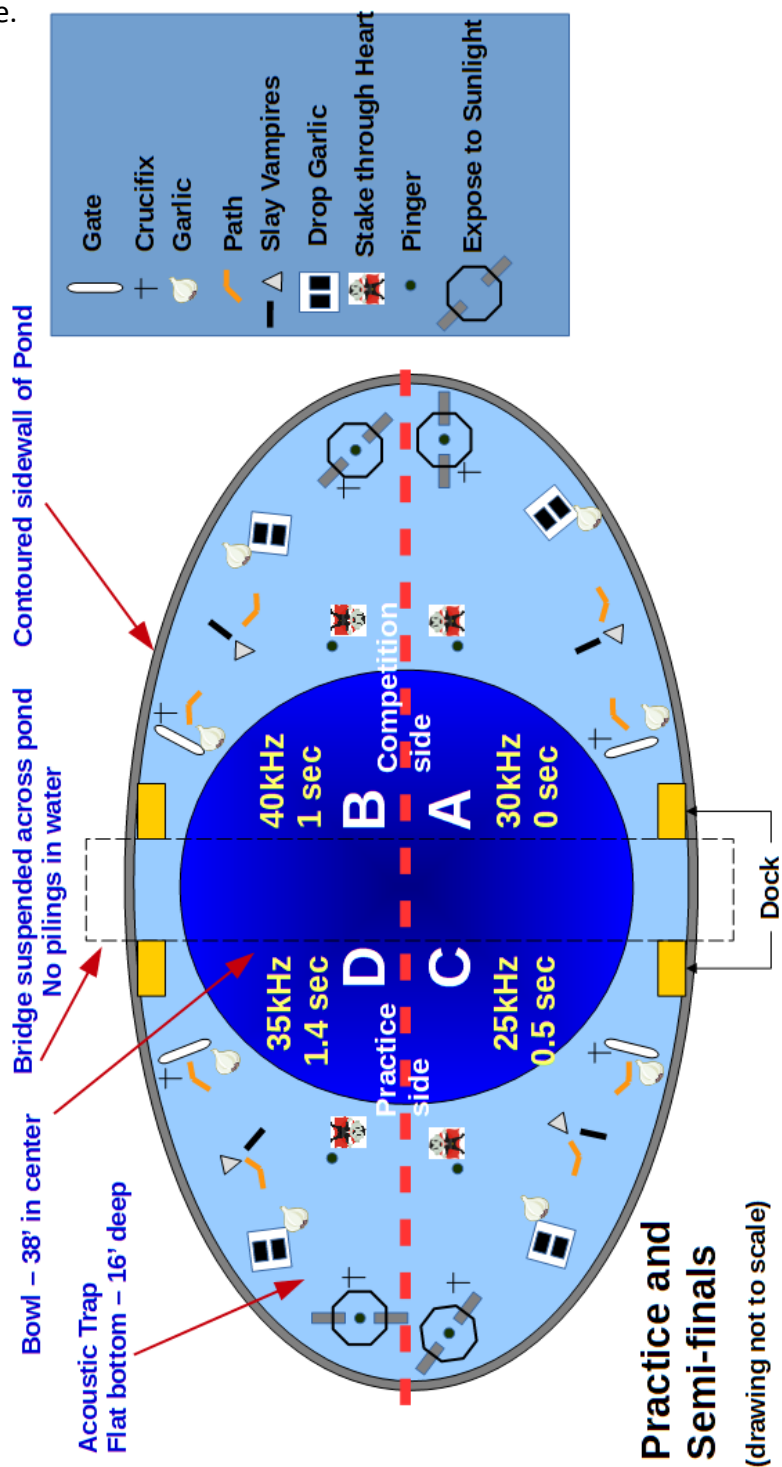


Figure 6: Course layout and pinger frequencies for Practice and Semi-finals

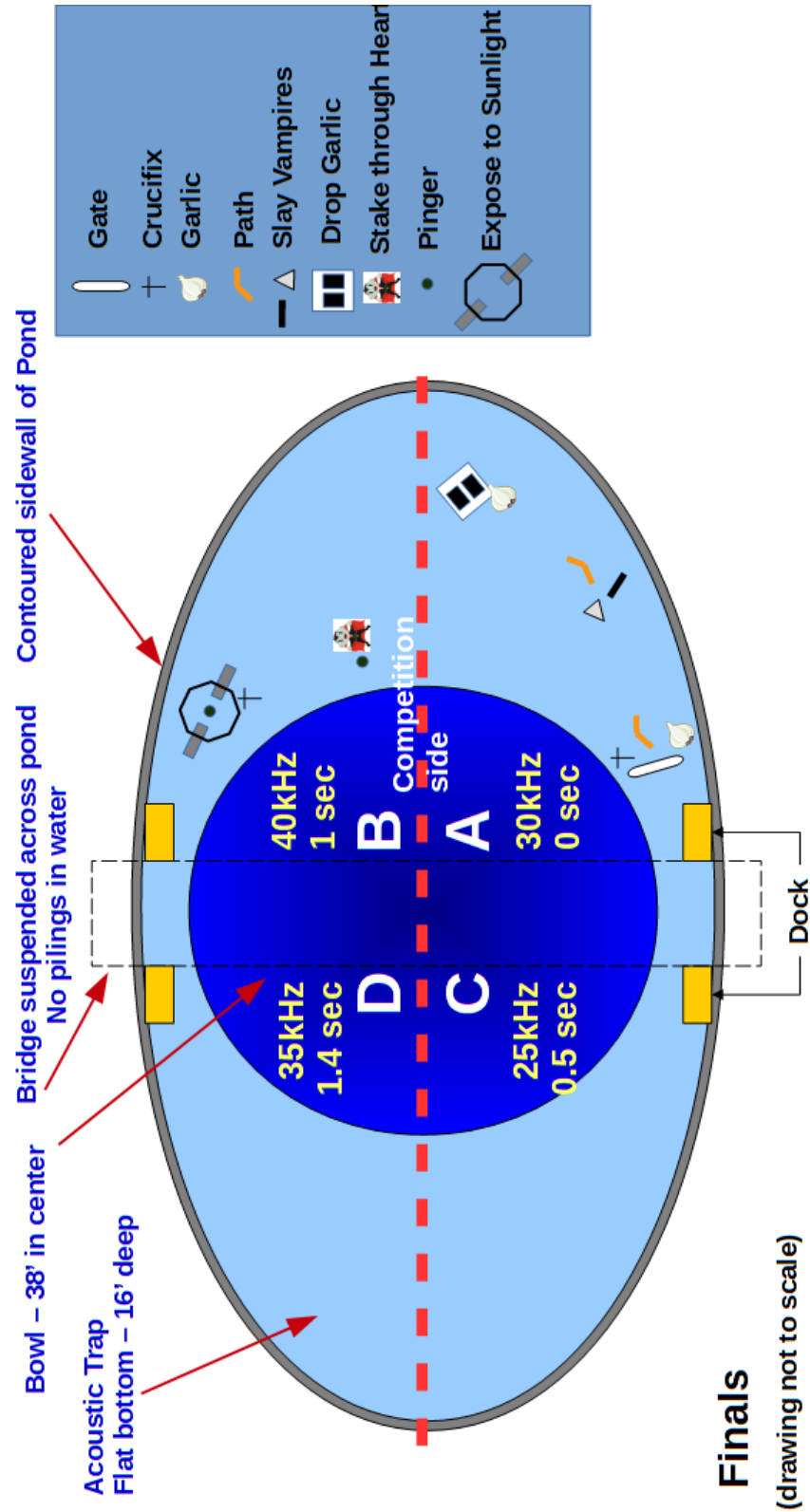
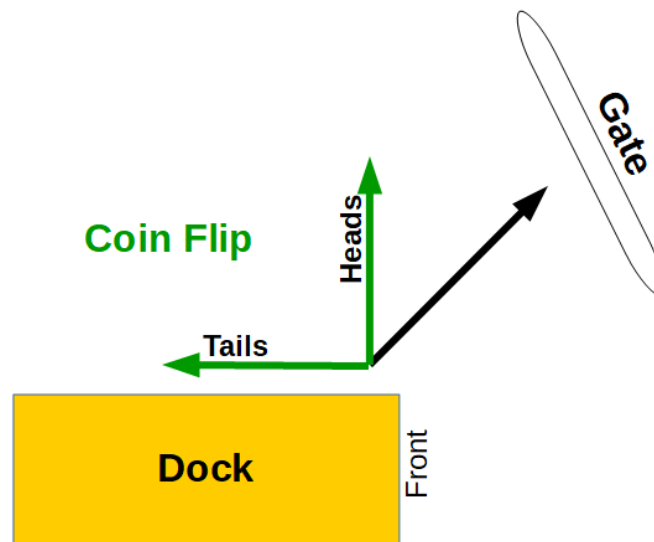


Figure 7: Course layout for Finals

9.1 Journey to the Undead Realm

From behind the front of the starting dock, a team may point their vehicle in any direction. Before the start of a run, and for additional points, teams may request a coin flip which will determine the heading of their vehicle for the start. If the coin lands on **Heads**, the vehicle is perpendicular to the dock. If the coin lands on **Tails**, the vehicle is parallel to the dock and points away from the gate. The team member on the dock or the diver in the water may position the vehicle. **NEW:** When starting a run, the vehicle must *submerge* first and then either head toward the gate or rotate to align with the gate and then head toward the gate.



(drawing **not** to scale)

Figure 8: Vehicle direction with coin flip

9.2 Enter the Undead Realm (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 colored **ORANGE**. The vehicle can pass through the gate at any depth from the floor to just below the surface.

A 2-inch PVC pipe is used to divide the gate into 40%/60%. A vehicle passing through the 40% section will receive more points than one passing through the 60% section. The bottom of the 2-inch PVC forms a plane. As long as part of the vehicle breaks the plane, points will be awarded for the section (40% or 60%) it passed through.

Style points are extra points that can be gained by passing through the gate with “style”. For every 90° change in orientation, the vehicle increases the multiplier, up to 8x. However, returning to the last previous orientation won’t count. I.e. a vehicle rolls 90° (+1 multiplier) and then back to 0° (+0 multiplier).

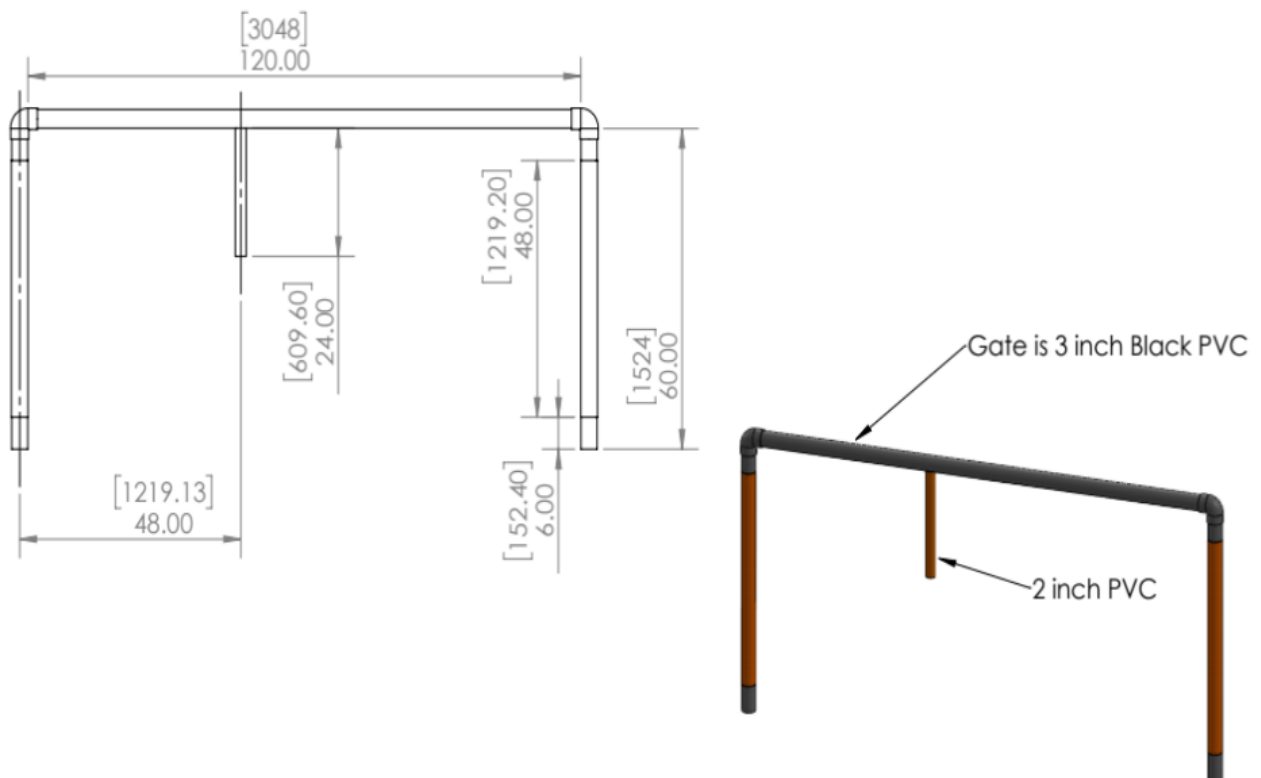


Figure 9: Validation gate.

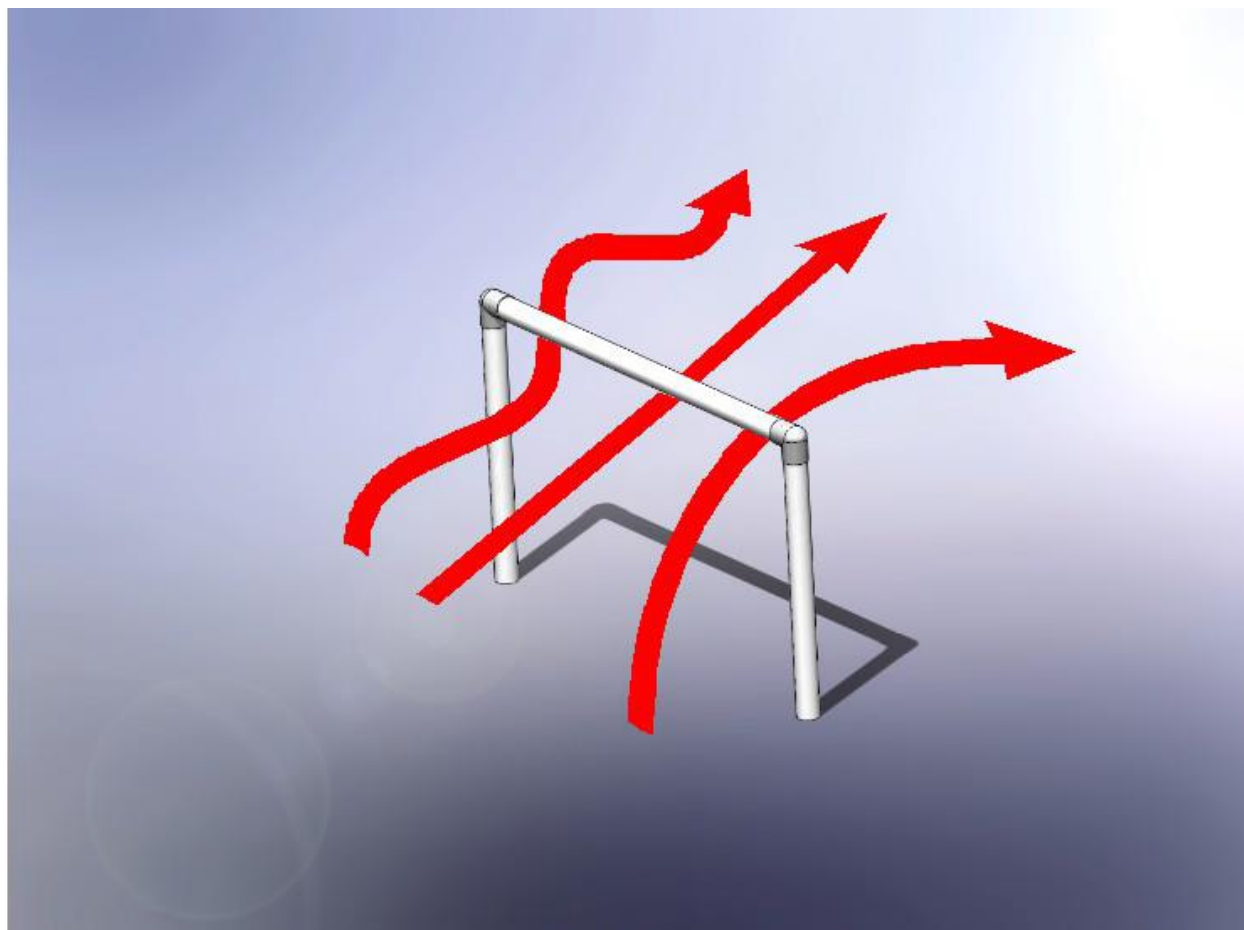


Figure 10: Valid ways to pass through the gate.

9.3 Pickups

There are two objects, crucifix and garlic, that can be picked up along the route and can be used for other tasks. The garlic objects can be dropped at the *Drop Garlic* task for additional points. The crucifix can be dropped in one of the caskets at the *Expose to Sunlight* task for additional points.

There will be one garlic and one crucifix located just after the gate. These can be picked up when the vehicle arrives at the gate. A second garlic is located at the *Drop Garlic* task and can be picked up when the vehicle arrives at the task. A second crucifix is located at the *Expose to Sunlight* task and can be picked up when the vehicle arrives at the task.

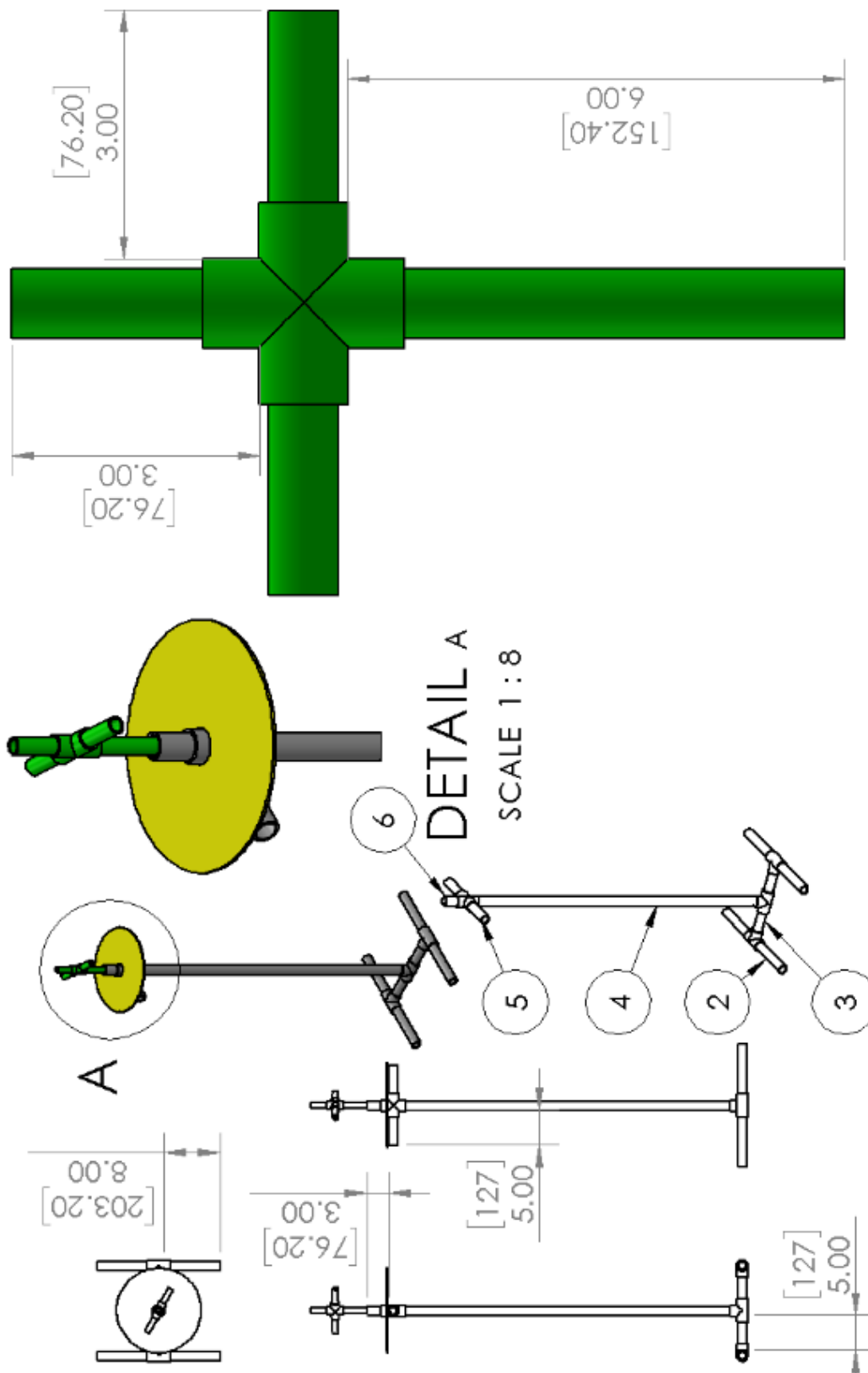


Figure 11: Crucifix object and tower

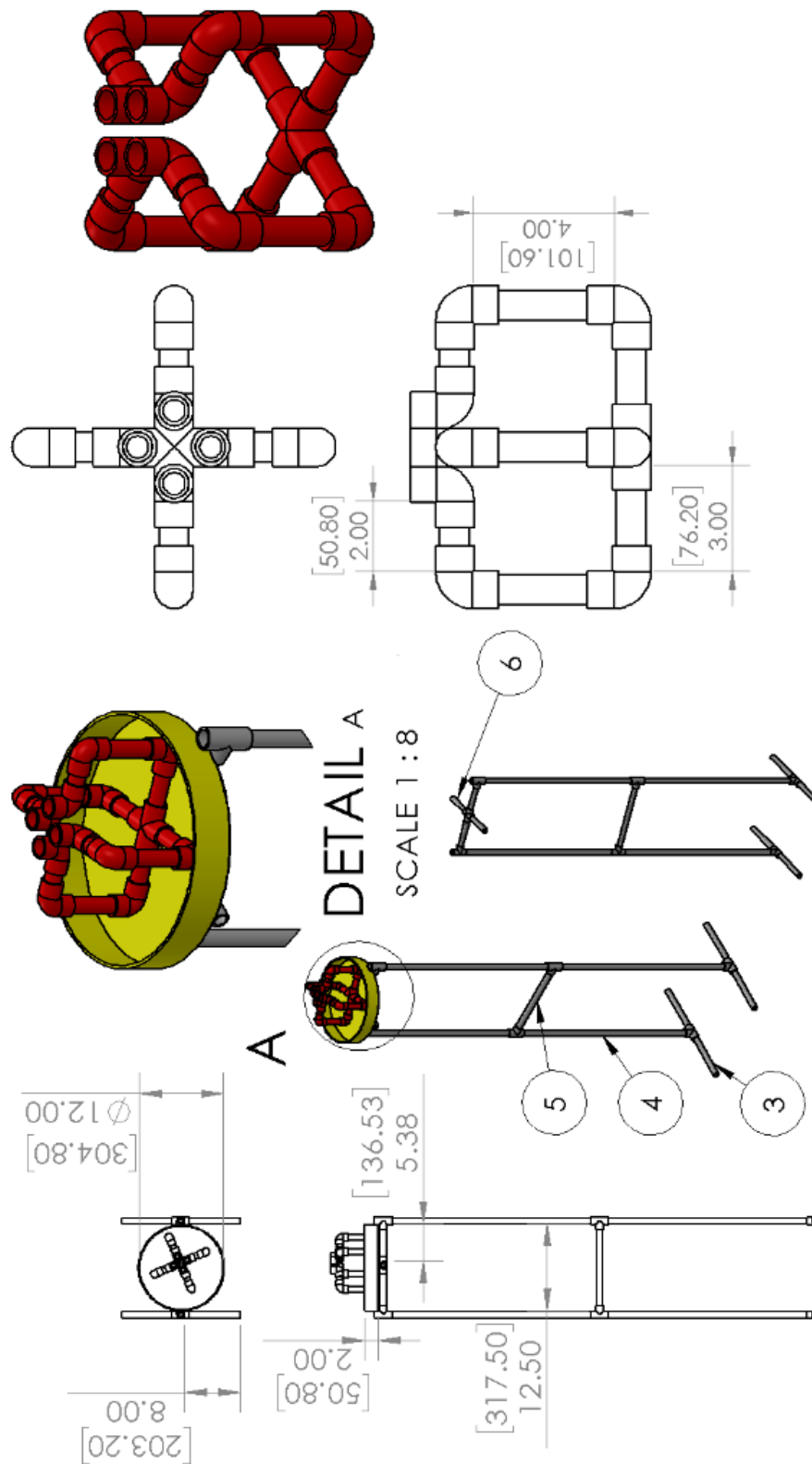


Figure 12: Garlic object and tower

9.4 Path

The path markers are ~4 feet (~1.2m) long by 6 inches (15cm) wide. The path will be colored **ORANGE**. Each path marker will be placed directly after the current task and point to the next task. The path markers will be in two sections. The second section will be $\pm 45^\circ$ from the first section. To obtain full points, the vehicle must follow each path segment, changing course as the path section changes.

There will be one positioned at the gate that points to the *Slay Vampires* (buoy) task. Positioned near the *Slay Vampires* task, the next path segment will point to the *Drop Garlic* task. Those will be the only path segments which can be used to visually orient the vehicle to the next task.

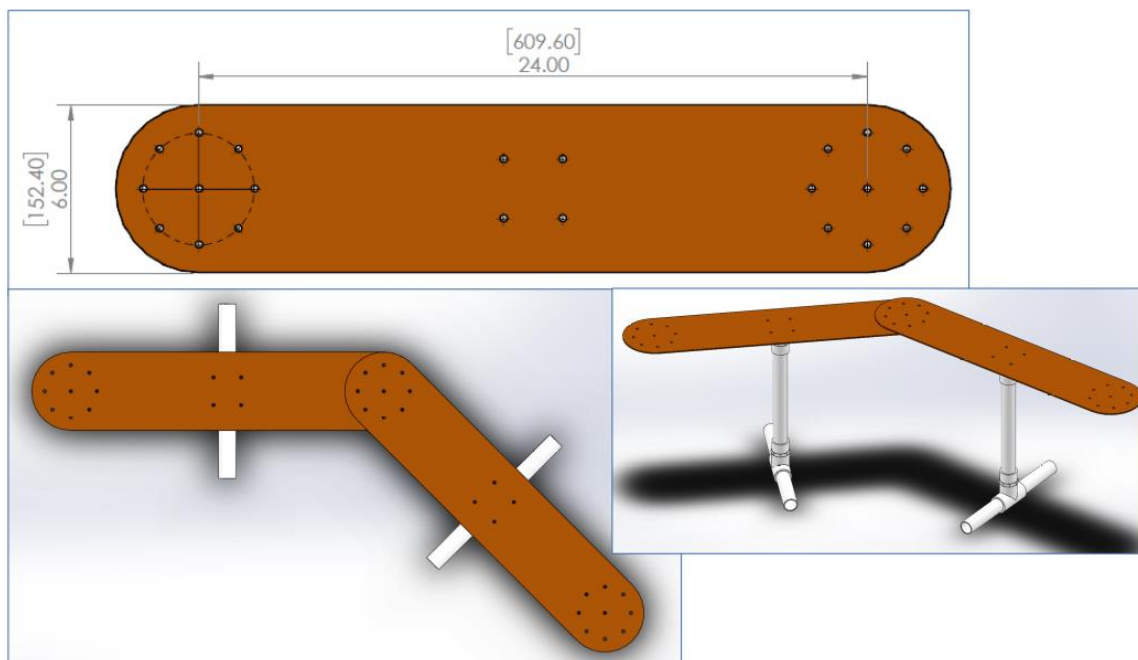


Figure 13: Path showing two sections.

9.5 Slay Vampires (Buoy)

There are two “buoys” that are moored to floor by line in two places. The single buoy will have the image of a Jiangshi on both sides. The three-sided buoy will have the image of an Aswang, Draugr, and Vet alas, (in that order, moving counter-clockwise around the triangle) one on each side. **NEW:** The three-sided buoy will be stationary, and a point of the triangle will point toward the gate.

Points are awarded for touching any buoy. Before the vehicle leaves the dock, the team may choose to select a face on the three-sided buoy (Aswang, Draugr, Vet alas). If the vehicle touches that side, more points are awarded, additional points are awarded for touching the back side of the triangle. Maximum points are awarded for touching the single buoy and the back-side called face on the three-sided buoy.

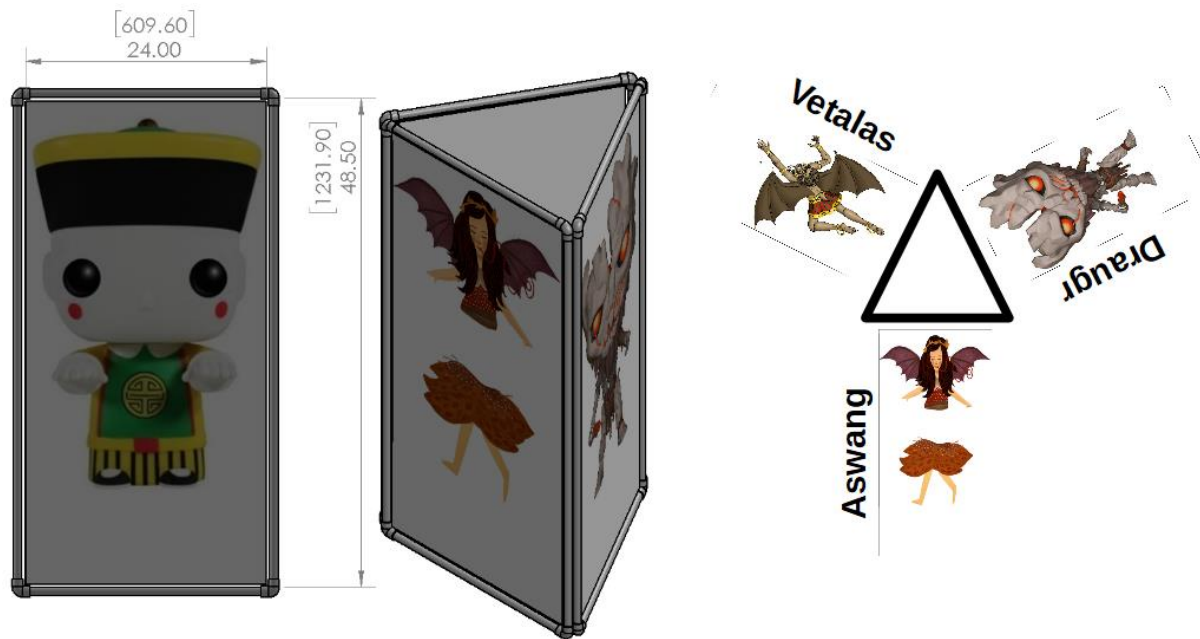


Figure 14: Slay Vampires

9.6 Drop Garlic (Bins)

This task consists of two bins that are held together in a frame. There is an image of a **bat** on one of the bins, and an image of a **wolf** in the second bin. A movable cover is always covering one of the bins. There is a lever that the vehicle can move in order to slide the cover from one bin to the other.

Points are awarded for dropping markers into the open bin (the markers can either be the two carried on the vehicle, or up to two garlic objects that were picked up along the way). Points are awarded for moving the lever from one side to the other. Maximum points are awarded for dropping markers (vehicle carried and garlic objects) into the once closed bin. For example, if the **bat** is covered and the vehicle moves the lever so that the **wolf** is now covered, maximum points are awarded for dropping into the **bat** bin.

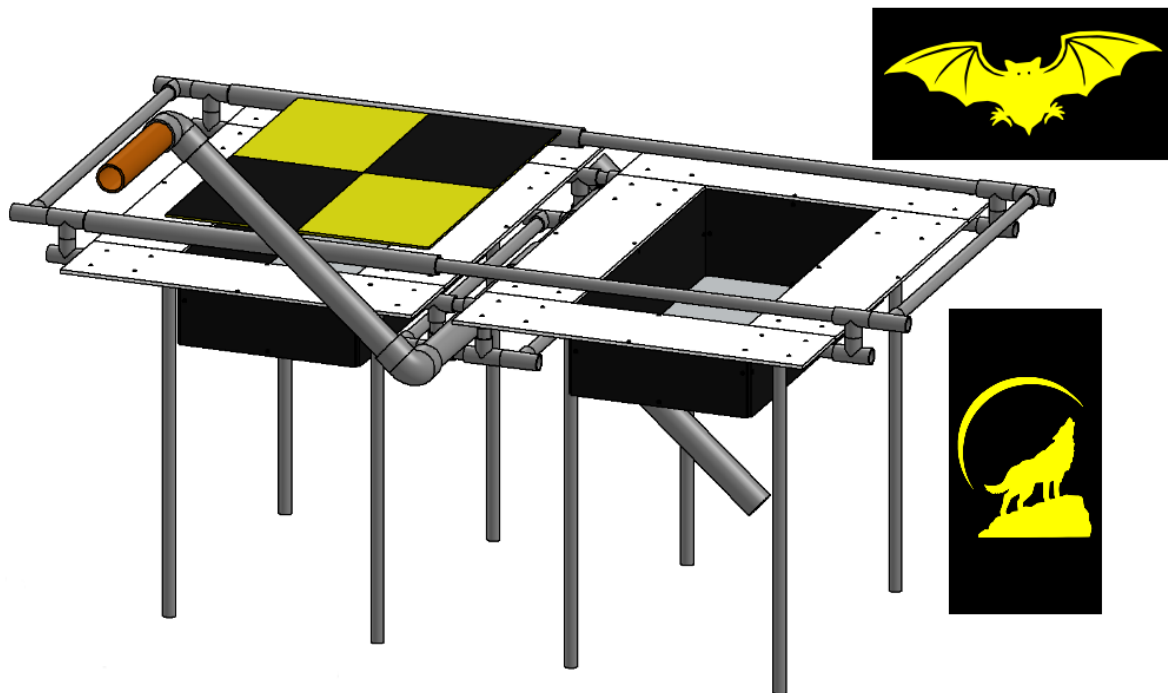


Figure 15: Drop Garlic task and bat & wolf silhouettes

9.7 Stake through Heart (Torpedoes)

An acoustic pinger will be used to guide the vehicle to this task. This task consists of a vertical board separated into two sections. The upper section has two oval cutouts, one oval is covered, while the other is open. The lower section has a heart-shaped cutout that is always open. The lever, between the two boards, can be moved left-right (decapitate Dracula) which opens one oval and close the other.

Points are awarded for firing torpedoes through the open oval. Points are awarded for moving the lever from one side to the other. More points are awarded for firing torpedoes through the heart. Maximum points are awarded for firing one torpedo through the heart, moving the lever and firing one torpedo through the currently open (which was previously covered) oval. For example, if the left oval is closed and the vehicle moves the lever from left to right (opening the left oval), fires a torpedo through the left oval and through the heart.

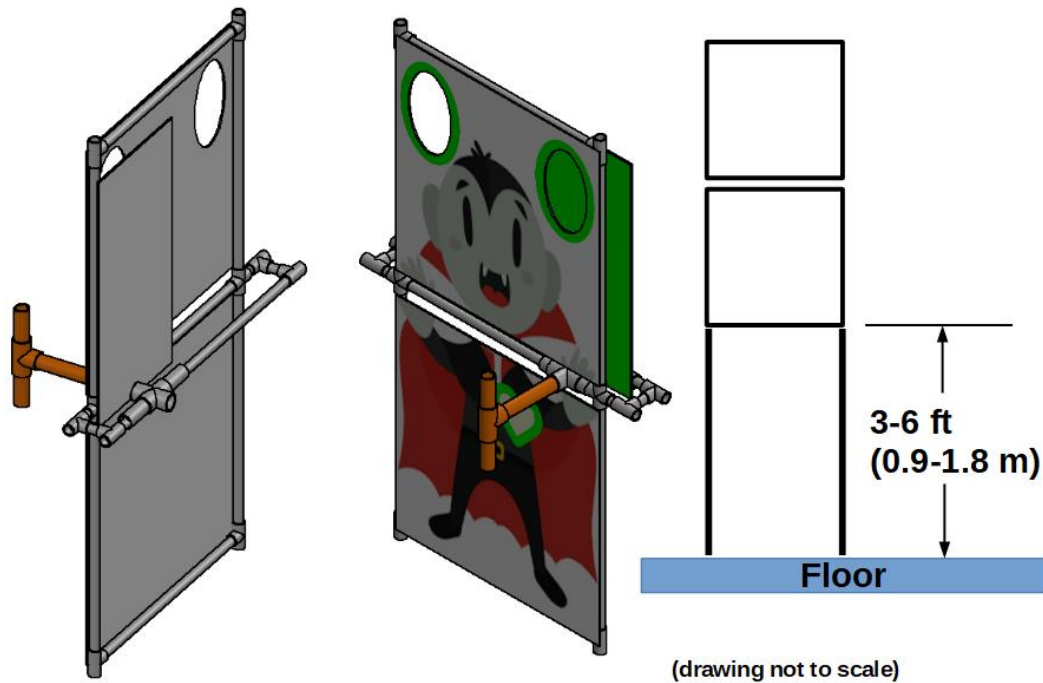


Figure 16: Stake through Heart

9.8 Expose to Sunlight

A 9 ft (2.7 m) diameter octagon floats on the surface and an acoustic pinger, located at the center of the octagon, will be used to guide the vehicle to this task. Located on opposite sides of the pinger are two coffins, one is open, the second is closed. Inside each coffin is Dracula (PVC structure). **NEW:** The closed coffin has a large handle. To open the coffin, the vehicle must grab the handle and lift up and out (rotate the lid), once it gets past vertical, the vehicle can release the handle. The lid is negatively buoyant and will fall open.

Points are awarded for dropping up to two crucifixes objects that were picked up along the way. The dropped crucifix must touch the coffin to obtain points. The crucifix does not need to remain in/on the coffin to obtain the points. Points are awarded for opening the closed coffin. Points are awarded for grabbing Dracula and surfacing inside the octagon. If the closed coffin is open, the second Dracula can be grabbed and taken to the surface inside the octagon a second time for additional points.

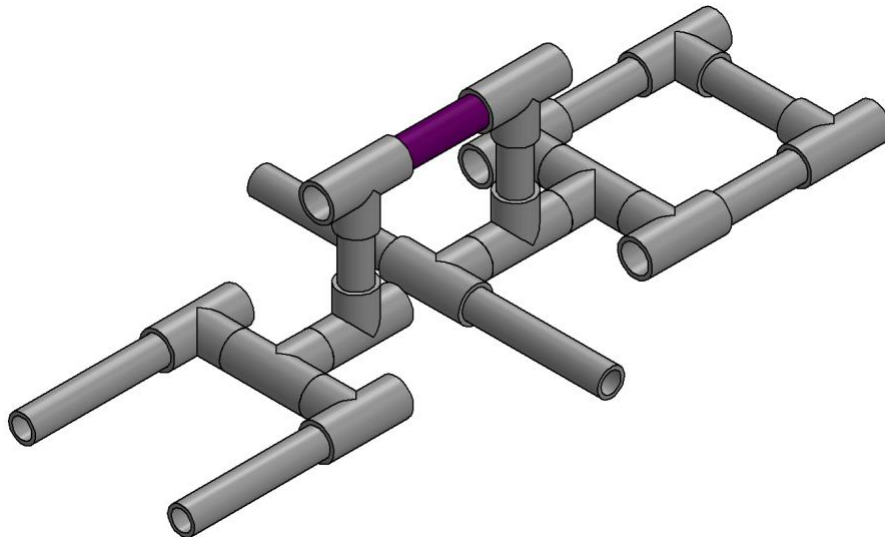


Figure 17: Dracula

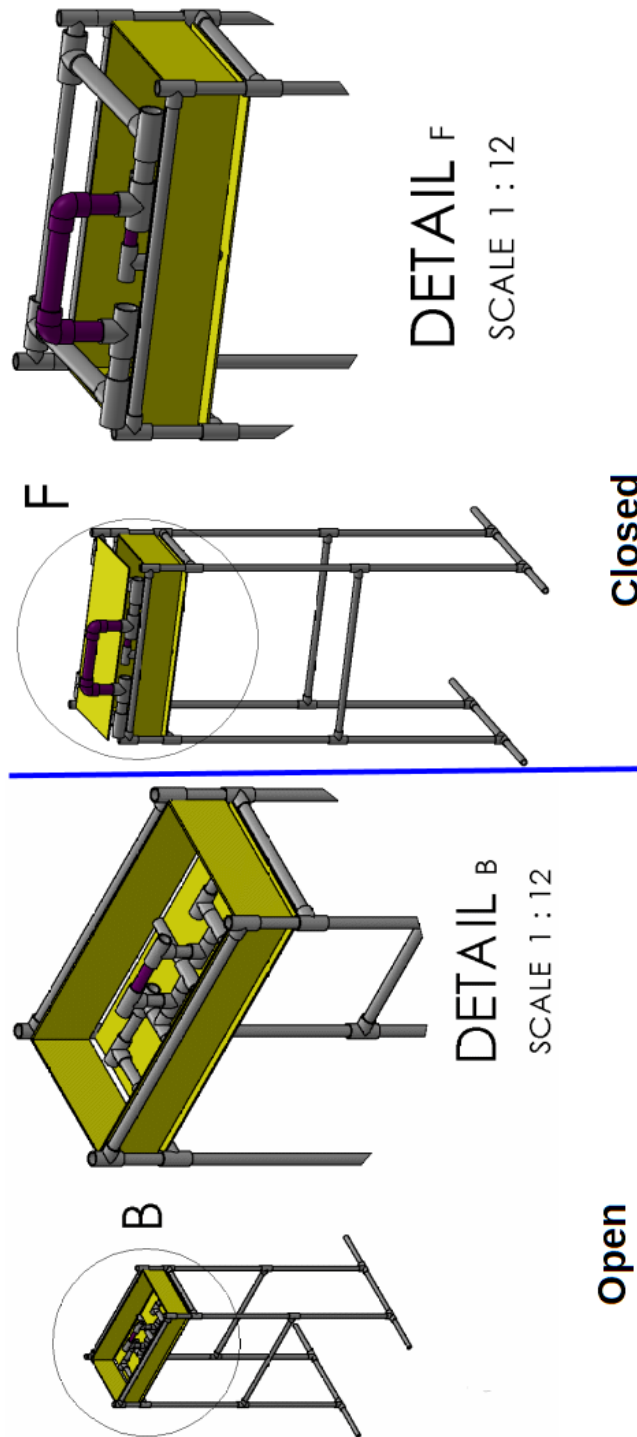


Figure 18: Open and Closed Coffin

10 Scoring

Each of the tasks has a point value associated with it. The tasks can be completed in any order by one or more vehicles. 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 lead may end 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 semi-final run, the points accumulated from the previous run are forfeit. The only points which are recorded are from the very last run.

For the finals, the **best** run will be used for the final points. Therefore, a team may try to accomplish as many runs as time allows, and the run that has accumulated the most points will be used for their final score. If the minimum requirements have been met, the remaining time after each run will be recorded and used to calculate a time bonus. For example, after the first run, a team has met the time bonus requirements with 10 minutes remaining on the clock. Those 10 minutes are used to calculate the time bonus for that run, regardless of what happens with the next run.

Stake through Heart and **Expose to Sunlight** 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 **Stake through Heart**, or pinger near **Expose to Sunlight**). At any time during the run, the team lead may ask to have the pinger switched to the other task. This switch can be done as many times as the team lead asks. However, additional points will be awarded if the team requests a random pinger.

If a vehicle can score points at both pinger tasks, the team lead may request a random pinger selection. The only randomization is the selection of the first task(s) marked with a pinger, the second task(s) will always be the other task(s) marked with a pinger. If the vehicle obtains any points from the first task(s), associated with the random pinger, bonus points are awarded. At any time after the vehicle has obtained points from the task(s) associated with the random pinger, the team lead may ask to switch the pinger. If the vehicle obtains any points from the second task(s), associated with the random pinger, bonus points are awarded. If the team lead 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 will be awarded.

10.1 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, places at least one marker in the bin (or fires a least one torpedo through the opening) and surfaces within the floating area 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*).

10.2 Breaching

When completing a sequence of tasks, a team may choose to complete the surfacing task (surface within the floating area) at any time. A vehicle may breach the surface within the floating area and then submerge again to complete the remaining tasks without risk of ending the run. For a vehicle to continue after breaching, it must surface inside of, or touching the floating area. A breach outside of the floating area will end the run of that vehicle. If there are multiple vehicles underway (and underwater) this does not end their run. The remaining vehicles may continue their own autonomous mission and continue to score points for that run. If the breached vehicle cannot be removed safely without interfering with the remaining vehicle(s), it will be allowed to continue its run, but will not score any more points for that run.

10.3 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 dock and start another new run. If a new run is begun, all points from the previous run are forfeit.

Point Breakdown

Table 2: Subjective Measures

Category	Maximum Points
Utility of team website	50
Technical Merit (from technical design report)	150
Written Style (from technical design report)	50
Capability for Autonomous Behavior (from static judging)	100
Creativity in System Design (from static judging)	100
Team Uniform (from static judging)	10
Team Video	50
Pre-qualification (you must qualify to receive points)	100
Discretionary static points (awarded after static judging)	40
Total	650

Table 3: Performance Measures

Task	Maximum Points
Weight	See Table 1 / Vehicle
Marker/Torpedo exceeding weight or dimensional specs by <10%	-500 / maker
Gate: Pass through	100
Gate: Maintain a fixed heading	150
Gate: Coin Flip	300
Gate: Pass through 60% section	200
Gate: Pass through 40% section	400
Gate: Style	+100 (8x max)
Collect Pickup: Crucifix, Garlic	400 / object
Follow the "Path" (2 total)	100 / segment
Slay Vampires: Any, Called	300, 600
Slay Vampires: Back of triangle	300
Drop Garlic: Open, Closed	700, 1000 / marker (2 + pickup)
Drop Garlic: Move Arm	400
Stake through Heart: Open Oval, Cover Oval, Sm Heart	800, 1000, 1200 / torpedo (max 2)
Stake through Heart: Move lever	400
Stake through Heart: Bonus - Cover Oval, Sm Heart	+500
Expose to Sunlight: Surface in Area	1000
Expose to Sunlight: Surface with object	400 / vampire
Expose to Sunlight: Open coffin	400
Expose to Sunlight: Drop Pickup	200 / object (Crucifix only)
Random Pinger first task	500
Random Pinger second task	1500
Inter-vehicle Communication	1000
Finish the mission with T minutes (whole + fractional)	Tx100

10.3.1 Subjective Measures description

See *RoboSub Technical Design Report Guidance* for descriptions on these requirements.

10.3.2 Performance Measures description

Passing through the validation gate: The judges' discretion will determine 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 correct for the vehicle's uncompensated 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 drift has not traveled straight through the gate.

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

Slay Vampires (Buoy): Partial points are awarded if you track the buoy(s) but you brush by, instead of a deliberate bump. Full points for touching the buoys and tilting them at least 10°. Manipulation of only the rope holding the buoys will not count for points (even if you touch the buoy after touching the rope).

Collect Pickups: Points are awarded for grabbing and holding on to the pickup object (Crucifix, Garlic)

Drop Garlic: Points are awarded based on where a marker finally comes to rest.

Stake through Heart: A torpedo must pass through the opening for full points. Partial points may be awarded if the torpedo touches the border without passing through.

Surface within the Area: The sub must fully surface within the floating area to obtain full point value. Partial points will be awarded based on how much the sub is inside the area.

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

Expose to Sunlight: The crucifix must touch the coffin after it has been dropped. Partial points may be awarded if the attempt is made, but the object falls close to, but does not touch, the coffin.

Inter-vehicle communication (IVC): When there are multiple vehicles in the water, they must communicate with each other in order to obtain IVC points (multiple vehicles are not *required* to communicate with each other). Proof of the communication must be presented to the judges to evaluate. Having indicator lights which help to draw attention when they are transmitting and receiving IVC messages would help with the confirmation (but are not required). The level of the communication and the complexity of the behaviors derived by the communication are what determines the level of points awarded.

Time Bonus: At a minimum, a sub must touch a buoy, drop at least one marker in the bin (or fire one torpedo through the cutout), and fully surface within the floating structure 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).