



# Official Rules and Mission AUVSI Foundation & ONR's 18<sup>th</sup> Annual RoboSub Competition

## “Back to TRANSDEC”

July 20 – July 26 2015

Space and Naval Warfare Systems Center

SSC SD TRANSDEC Facility

San Diego, CA

### Goals

The goals of the AUVSI Foundation's student competitions are to provide opportunities for students to experience the challenges of system engineering, to develop skill in accomplishing realistic missions with autonomous vehicles and to foster relationships between young engineers and the organizations developing and producing autonomous vehicle technologies.

The primary emphases of the AUVSI Foundation's student competitions are learning and outreach. These events are not grand challenges designed explicitly to progress the state-of-the-art. The objective is to produce the people who will push the envelope in the future. Major innovations may be spawned in these events, but this is a by-product, not an objective. Most important are gaining an appreciation for the trade offs inherent in any system design and the lessons learned in transitioning from a working bench prototype to operating reliably in the real world.

When competitiveness and collegiality are in balance, learning is maximized. The AUVSI Foundation's competitions strive to maintain this balance. The nominal winners are those teams that have scored the most points. The real winners are all those participants who have learned something lasting about working together to create an autonomous system that accomplishes a challenging mission in a complex environment.

The legacy of the student competitions can be found today throughout government and industry. Employers and venture capitalists seek out prospects with the kind of resourcefulness and team management experience that former competitors offer.

### Points of Contact:

[Dr. David Novick](#)  
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**Technical Director**, Sandia National Labs – rules, procedures, specifications

**Executive Director**, AUVSI Foundation – coordination

**Competition Logistics**, AUVSI Foundation – team registration, general information

**Marketing**, AUVSI Foundation – marketing, media requests, sponsorship



## Checklist & Due Dates for RoboSub

☐ **Registration Form, Payment, Resume** **Wednesday, April 1**

☐ **Team Roster and T-shirt size** **Monday, May 18**

☐ **Hotel Reservations (Holiday Inn San Diego Bayside)** **Wednesday, June 10**

☐ **Team Website, Introductory Video and Journal paper** **Friday, June 19**

☐ **Team Orientation and Check-in 1600-1800 (4-6pm)** **Monday, July 20**

☐ **Practice day (Qualifying runs)** **Tuesday, July 21**

☐ **Practice day (Qualifying runs)** **Wednesday, July 22**

☐ **Practice day (Qualifying runs)** **Thursday, July 23**

☐ **Static Judging** **Thursday, July 23**

☐ **Static Judging & Semi-Final 1** **Friday, July 24**

☐ **Semi-final 2** **Saturday, July 25**

☐ **Finals (1300-1700)** **Sunday, July 26**

☐ **Awards Banquet (1900-2200)** **Sunday, July 26**

Visit RoboSub team central for the most up-to-date deadlines

[www.RoboSub.org](http://www.RoboSub.org)

Join in on the discussions at RoboSub 2015 Google+

## SCHEDULE

Teams will register at the mandatory Team Check-in & Orientation meeting. Practice time will be all day on practice days (and both sides of the arena will be set-up for practice runs). Safety inspections will be conducted when a vehicle is brought up to the staging area to be lowered into the water. Depending on the number of competitors, a vehicle may need to autonomously pass through the gate once during the practice days in order to advance to the semi-final rounds. (see Drawing 5). Make sure the technical director or representative is watching your autonomous run. Based on performance, teams will be selected to compete for the Finals round. As usual, the Awards Party will take place Sunday evening after the finals.

## Theme

The theme for this year's competition is derived from the **Back to the Future** movie trilogy. The franchise follows the adventures of a high school student, Marty McFly, and an eccentric scientist, Dr. Emmett L. Brown as they use a DeLorean time machine to time travel to different periods in the history of Hill Valley, California. In the first movie, Marty is accidentally sent back in time from **1985** to **1955**. The series continues as Doc Brown travels with Marty (and Jennifer) to the year **2015**. The pair must travel back to **1955** to set a few things straight. When the duo are about to travel back to **1985**, a lightning bolt strikes the DeLorean and activates the time circuits, sending Doc back to **1885** and leaving Marty stranded once again in **1955**.

## 1. MISSION & ARENA

The fundamental goal of the mission is for an AUV to demonstrate its autonomy by completing an underwater “Back to the Future” mission. The vehicle will be able to stop and check the flux capacitor (dock/interact with buoys), pass through the time portal (reach 88 mph and pass over an obstacle), refuel (drop markers), set the correct year (fire torpedoes through a cutout), and find a way to return home (find a pinger, grab an object and move/release the object).

### 1.1 Splitting the Arena

The venue is large enough to operate vehicles in both halves of the arena at once. The layout in the two halves will be quite similar, as shown in Drawing 3. To increase the number of teams at any given time, we will operate vehicles in both halves of the arena at once.

During the practice days, both sides will be arranged in the practice configuration. For the semi-final rounds and final round, the tasks will be adjusted for the semi-final rounds and again for the final round. Depending on the number of teams, the practice side could also be used for semi-final rounds. If our staffing permits, teams that are not making their semi-final run will be allowed to practice during the semi-final runs.

### 1.2 Starting Point

Each vehicle will be started from the launch platform, whose approximate location is indicated on the arena plan.

## 2. DESCRIPTION OF TASKS

The tasks will be placed in such a way as to not have any three elements along a single line.

### 2.1 Gate

This task consists of a 3” (7.6 cm) black PVC pipe in the shape of a gate (hence the name). The Gate will be just slightly below the surface of the water (see Drawing 4). The vertical arms are covered with **Blaze Orange** Duck tape. The Gate will be positioned just beyond the Launch Platform.

Before proceeding to **any** other task, the autonomous vehicle first pass through the gate. To obtain maximum points the vehicle must pass straight through the gate. Partial points will be awarded for hooks, swerves and loops through the gate. The vehicle is not required to pass within the boundary of the gate (as defined by the PVC structure). For example, the vehicle may dive to a depth of 10ft (3m), well below the edge of the vertical legs, while passing through the gate.

## 2.2 Guide

This task consists of path segments constructed from aluminum sheet snaking their way through all of the tasks. There will also be a path segment from each octagon pointing toward the railroad track which will be positioned between the two octagons.

The “path” will be constructed of 6 inch (15 cm) wide by 4 feet (1.2 m) long sections of aluminum sheet. It will be covered with **Blaze Orange** Duck tape. The “path” is raised off the floor of the pool 1-2 feet (0.3-0.6 m) and each segment will not have a relative angle between two pieces of more the 90° (except for the segments which point between the path split). The segments are situated in such a way that if you follow a heading along the line segment you will (eventually) meet with the next task. The next path segment will be located on the “far side” of the obstacle 1-3 ft (0.3-0.9 m). Distances between segments will vary depending on the positioning of the tasks. The order of the tasks will always be: Check Flux Capacitor, Time Portal, Refuel/SetDate, and Return Home. You may complete the tasks in any order (with the Gate required to be first before starting anything else).

## 2.3 Check Flux Capacitor (Buoy)

This task consists of three moored solid color buoys (“**red**”, “**yellow**”, “**green**”).

To receive the maximum amount of points, the vehicle must touch the colored buoys in the proper sequence. The colored sequence will always be **Red** then **Green**. The last two solid color buoys touched will be the ones that count for points for that portion of the task. The buoys are constructed so that they can take a decent blow. The mooring line will either be nylon webbing or 550 paracord to minimize the chances of the vehicle becoming entangled. You may hit the buoys from any direction.

## 2.4 Time Portal (PVC to pass over)

The task consists of a 2” (5.1 cm) diameter, 8ft (2.4 m) long PVC pipe with two long vertical floating risers on each end and a shorter vertical floating riser in the middle. All three risers will be tied to the horizontal section and be free to move. The yellow vertical risers on the end will be 4ft (1.2m) long tied to the horizontal section. The shorter red middle riser will be 1ft (0.3m) long tied to the middle of the horizontal section. The PVC is colored using **Yellow** and **Red** tape and vinyl.

To score points you must pass over the horizontal section. Points will be awarded for the center-line or more of the vehicle passing below the top of the highest riser. More points will be awarded for sliding sideways or backward through the portal (with style!). In order to obtain style points, the vehicle must pass through over the PVC at a greater than 45° angle (along roll, pitch or yaw).

## 2.5 Refuel (Bins)

This task consists of a **BLACK** bin surrounded by a white border. The bins will be 1-2 feet (0.3-0.6 m) off the bottom. The four bins will be aligned in a single row (see Drawing 3). In each bin, there will be one silhouette. There will be a lid covering one of the bins. The lid will be **Orange** while the handle will be **Purple**. The lid will be slightly negatively buoyant. Weights or floats will be on the underside of the lid to adjust it's buoyancy. Because of this, the lid must be first picked up to be removed. It can not just be slide off the top of the bin.

A vehicle may carry up to two markers to drop within the bins. One silhouette will be designated as the primary target, and one will be designated as the secondary target. The lid will **always** cover the primary target. The most points will be awarded for dropping one marker on the primary target, and one on the secondary target. Partial points will be awarded for dropping markers in any bin.

## 2.6 Set Date (Firing torpedoes)

This task consists of a single 4ft (1.2m) square **Yellow** board. Arranged on the board will be two small square cutouts and two large square cutouts. There will be a 1" (2.5cm) **Red** border around each cutout. Above each square will be the first half or the second half of a year (1885, 1955, 1985, 2015). Each small square or large square will have half a date over it (similar date for each set of small and large squares). For example, If the date was 1985, there would be 19 over one each of the small and large opening, and 85 over the remaining small and large opening. There will be a door covering over **one** of the small openings. The door slides horizontally to uncover the opening. The door will be **Orange** while the handle will be **Purple** (similar to the lid over the Primary bin). The **Purple** handle will always be orientated vertically (see Drawing 11). A vehicle may just push the door aside (and completely off) to uncover the opening.

A vehicle may carry up to two torpedoes to fire. Points will be awarded for firing torpedoes through any opening. Maximum points are awarded for firing torpedoes through each of the small openings (requiring the door to be slide open to uncover the opening) in the proper order for the date (so if the date was 1985, then the vehicle must fire the first torpedo through the "19" opening, and the second through the "85" opening). Partial points will be awarded for setting the proper date using the open large and small squares.

## 2.7 Recovery Area (object recovery and octagon)

This task consists of an acoustic pinger located 2 ft (0.6 m) off the floor. Floating above the pinger, on the surface will be a single octagon representing the Return Home. The octagon will be constructed from ½" PVC pipe and have a "diameter" of 9 ft (2.74 m). Each side could have two octagons and two pingers placed in different locations. At the start of each run, only one of the two pingers on each side will be turned on. The team captain can choose to switch the active pinger at any time.

Positioned directly above each pinger will be a fixture which holds either the **Orange** DeLorean automobile or **Yellow** Train. Located between the two fixtures will be a 4ft (1.2m) **White** square with a **Black** Railroad track. From each of the Return Home areas will be a Blaze Orange path segment pointing to the Railroad Track.

Maximum points are awarded for setting the DeLorean in front of the Train on the Railroad Track (as show in Drawing 13). Partial points are awarded for any other combination.

In order to obtain full points for surfacing, your vehicle must surface fully inside the octagon (no portion of the sub touching the structure). In order to obtain full points for recovery, the object must be captured (maintains control) by the vehicle when it surfaces. A capture consists of constraining the object in at least 3 degrees of freedom (grabbing the object with a dangling line does not count). In order to obtain full points for the drop off, the object must be released from the vehicle and sink back down (the object must first be properly recovered in order to drop it). No part of the object can be hung up on the vehicle.

The competition and practice side will ping at a rate of 0.5 Hz (2 seconds), and will be separated by 0.9 seconds. The pingers will be synchronized. The schedule will be:

|                      |               |
|----------------------|---------------|
| Unit 1 (Competition) | ping t = 0s   |
| Unit 2 (Practice)    | ping t = 0.9s |
| Unit 1 (Competition) | ping t = 2.0s |
| Unit 2 (Practice)    | ping t = 2.9s |
| Etc.                 |               |

This give the reverbs from each pinger (near) maximum time to die out. Note that for the final runs, the competitors will have the choice to keep the practice pinger on, or turn that side off.

## 2.8 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 in an objective, the run will be declared completed. Teams may keep the points earned on that run, or may have the AUV returned to the launching platform and start another new run. If a new run is begun, all points for the previous run are lost. See "Official Rules, Submissions and Fees" for more

information on interference.

## 2.9 Acoustics

The pingers that we will use will be Teledyne Benthos [ALP-365](#) pingers.. They can be set from 25-40 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, 40).

# 3. Weight and Size Constraints

## 3.1 Vehicle

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:** Size and weight constraints on AUVs entered into the competition.

|   | Bonus  | Penalty  |
|---|--|--|
| AUV Weight > 125 lbs<br>(AUV Weight > 56.7 kg)              | N/A  | <b>Disqualified!!!</b>                                     |
| 125 lbs ≥ AUV Weight > 84<br>(56.7 kg ≥ AUV Weight > 38 kg) | N/A  | <b>Loss of</b><br>250 + 5(lb – 125)<br>250 + 11(kg – 56.7) |
| 84 lbs ≥ AUV Weight > 48.5<br>(38 kg ≥ AUV Weight > 22 kg)  | <b>Bonus of</b><br>2(84 – lb)<br>4.4(38-kg)            | N/A  |
| AUV Weight ≤ 48.5 lbs<br>(AUV Weight ≤ 22 kg)               | <b>Bonus of</b><br>80 + (48.5 – lb)<br>80 + 2.2(22-kg) | N/A  |

## 3.2 Markers

Each marker must fit within a box 2.0” square and 6” long (5.08 x 5.08 x 15.24 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 or an 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 back ups.

## 3.3 Torpedoes

The torpedoes 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.

# 4. OFFICIAL RULES, SUBMISSIONS AND FEES

1. The official source for all information concerning rules, interpretations, and information updates for the International Autonomous Underwater Vehicle Competition is the World Wide Web home page at: [www.RoboSub.org](http://www.RoboSub.org)
2. A Registration form, available on the website, and the entry fee must be completed. The submission



must be in English and is not considered official until the entry fee has been received by AUVSI Foundation. As the competition format cannot handle an unlimited number of entries, the organizers reserve the right to limit the total number of entries that are allowed to compete by declaring the competition closed to new entries before the due date above. As with all official information, this announcement (should it be necessary) will appear on the official website.

3. 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 left floating while the vehicle is underway.
4. Teams may comprise 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 joint team must make significant contributions to the development of their vehicle.
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. Only the student component of each team is eligible for the cash awards.
7. 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.
8. The officials will suspend the competition at any time they deem that it is required by safety or security considerations.
9. 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. We anticipate that three to five teams will be accepted into the finals.
10. Depending on the number of contestants, in order to be considered for selection in the semi-final round, a vehicle must show that it can submerge and pass through the gate during the practice days. 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 on the official website.
11. 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 are not accepted into the final round.
12. 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.**

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 loses any unused time in the preparation period.

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

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.
14. Ending a run and retrieving a vehicle: At any time while the vehicle is running, 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 team establishes communication with the vehicle, or the vehicle is safely back at the dock, 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).
15. Depending on the time, a team may use any of their 15-minute-long performance period time to survey the arena. The survey, however, 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.**
16. If a vehicle experiences a significant interference from a piece of equipment, line, cable or diver deployed in support of the competition, the team captain may ask, at that time, to have the clock stopped, the vehicle returned to the dock, and for the judges to add back to the clock their best estimate of the time used in that run up to the point of interference. If the team captain does not make this request in a timely manner (as determined by the technical director or his designee) then the option is lost. Interference with a gate, light, or target object does not qualify for this option, and a vehicle interfering with those items may be disqualified at the judges' discretion.
17. 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).

#### **4.1 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!)

#### **4.2 Power**

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





### 4.3 Vehicles

1. Each team may enter only one vehicle into the competition. Each vehicle will be physically-inspected by the competition judges. The judges may disqualify any vehicle that they deem to pose an unreasonable safety hazard.
2. The judges will confer with representatives of the host facility, and any vehicle that, in the opinions of the judges or the representatives of the host facility, pose an unreasonable risk to the integrity of the host facility will be disqualified. The AUVSI and the host organization, their employees and agents, as well as the organizing committee, are in no way liable for any injury or damage caused by any vehicle, nor for any damage or injury caused directly or indirectly by the disqualification of a vehicle.
3. During a qualifying, semi-final or final run, each vehicle must operate autonomously during its dive. While carrying out the mission, no communication is permitted between the vehicle and any person or off-board computer. Vehicles must operate solely on their ability to sense and maneuver in the arena using on-board resources. 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 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 a box that is 6 feet long, 3 feet wide, and 3 feet deep (1.83m x 0.91m , 0.9m).
5. All vehicles must be battery powered. All batteries must be sealed to reduce the hazard from acid 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 (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 organizing committee.
6. No materials (except for the markers/torpedoes and compressed air used to blow ballast) 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 any other person.
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 readily activate. The switch must disconnect the batteries from all propulsion components and devices in 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" (5.08 cm) 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, 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 of one percent (0.5%) of their mass when they have been shut off through 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. **NEW!** Multiple vehicles 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:
  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 competition 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 timer 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 the last vehicle is back at the dock.
  5. 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). Frequencies that are always off limits for inter-sub communication are the frequency range used by the pingers.

#### **4.4 Journal Paper**

1. Each team is required to submit a journal paper in English that describes the design of their vehicle and the rationale behind their design choices. This paper may be no more than 10 pages long (including all figures, reference, and appendices). Additionally, each journal paper must include an abstract of no more than 250 words. The journal paper and abstract must be “printed” on standard 8.5 x 11-inch paper, with margins of at least 1 inch on all sides, and all text must be 12-point or larger font. Each page must bear a footer with the page numbering and the team name. The journal paper will be evaluated as described below in the section on scoring.
2. The journal paper must be received in pdf format via email. Teams that do not meet the deadline may be disqualified from the competition.
3. Along with the paper, each team will also submit a video. The video will introduce the team and their approach to the event. This video will be scored and will be used online and on-site during the webcast. It will not be used for the oral presentation. This video should introduce the team, their craft, as well as special features and/or strategies for the competition. The video should have good quality audio with as little background noise as possible (ideally making use of an external mic plugged into the camera rather than using an internal camera mic) and steady shots using a tripod or stabilizing equipment whenever possible. Visit RoboSub team central (<http://www.auvsifoundation.org/robosubTeamCentral>) for instructions on how the final video should be compressed, and where it should be uploaded.

#### **4.5 Resumes**

1. One goal of the competition is to foster links between young engineers and the companies, universities, and government agencies involved in AUV development. To advance that goal, we request that each team provide resumes of each team member, along with class year and expected graduation date.

These resumes (when submitted) will be circulated to our sponsors and employers who will be considering opportunities for full-time employment, internships and co-op programs. Your participation in this program is strongly encouraged.

2. Electronic versions of team member resumes should be zipped together with the journal paper.
3. Students are also encouraged to use AUVSI's Online Career Center at <http://careers.auvsi.org>

#### **4.6 Static Judging**

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

## **5. SEQUENCE OF EVENTS DURING THE COMPETITION**

### **5.1 Static display period**

Each team will receive a visit from the judges during this period for the static judging. Additionally, members of the public, the press, and representatives of other organizations will be encouraged to view the vehicles and talk with team members. The judges may all work together or break apart into small groups resulting in multiple judge visits per team.

### **5.2 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 for the arena. Each vehicle must be approved by the technical director or the designee before it will be allowed into the arena.

If required, this is the time for the vehicle to pass through the gate autonomously to be eligible for time slots for the semi-final rounds.

### **5.3 Time slots announced for competition runs**

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

### **5.4 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.

## **5.5 Recovery of Vehicle**

The team captain can call 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 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.

Vehicles will be put into and taken out of the water by tournament officials. The time required to do so will not count against the **performance time** limit. If a vehicle is in the water, the team may request that it be lifted onto the dock. Tournament officials will move the vehicle onto the dock and (when requested) re-deploy the AUV into the water. Again, the time required to move the vehicle into and out of the water will not count against the **performance time** limit. However, time spent by the team on the dock does count against the **performance time** limit. The exception is when the vehicle is performing an autonomous survey, the clock will continue to run while the vehicle is retrieved.

## **5.6 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 captain requests the end of the mission, or the judges order the termination of the mission, or the vehicle breaches the surface. The judges may order termination of the mission at their discretion. Once the judges order the end of the mission, no further points may be scored. The judges' decisions on the termination of the run are final.

## **5.7 Final round of the competition**

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

# **6. SCORING**

## **6.1 Breaching**

When completing the sequence of tasks, a team may choose to complete the surfacing task first (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 would end the run.

## **6.2 Final Round**

After the semi-final round, the judges will rank-order the teams based on their scores from the semi-final round, and select the top teams (as deemed by the judges) to compete in the final round. The point totals and ranking for 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 score 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.

### 6.3 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                      |
| <b>Total</b>   | <b>400</b>              |
| Performance Measures   | Maximum points          |
| Weight   | See Table 1             |
| Marker/Torpedo exceeding weight or dimensional specifications by < 10%     | -500 per marker         |
| Pass through the validation gate   | 100                     |
| Maintain a fixed heading through gate                                      | 150                     |
| Follow the "Path"  | 100 /segment            |
| Check Flux Cap (any solid, Red than Green)                                 | 400, 800                |
| Time Portal (>½ above, <½ below & parallel) Straight through // with Style | 400, 600 // 1000, 1400  |
| Refuel: remove lid   | 700                     |
| Refuel: any, primary/secondary   | 500, 1200 / marker      |
| Set Date: remove lid   | 700                     |
| Set Date: any, corr lg, corr sm  | 500,1000,1500 / torpedo |
| Surface within an Octagon  | 500                     |
| Surface within the correct Octagon   | 2000                    |
| Surface with the Object  | 600 / object            |
| Drop the Object  | 200 / object            |
| Object on Railroad   | 1000 / object           |
| DeLorean in front of Train on Railroad Track                               | 1000                    |
| Finish the mission with T minutes (whole + fractional)                     | T x 100                 |

#### 6.3.1 "Subjective Measures" description

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

that is, in the opinion of the judges, well suited to the engineering needs of the vehicle.

### 6.3.2 “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?

**Follow the “Path”:** How well did the vehicle find/follow the segments?

**Check Flux Capacitor:** Full points for touching the buoys. Partial points are awarded if you track the buoy but you brush by instead of a deliberate bump.

**Time Portal:** Did the vehicle pass over the PVC without touching it? What percentage of the vehicle passed over the top of the object?

**Refuel:** There is only one correct primary target and one correct secondary target, two markers in either one only counts once. Two markers in any other bin will count twice.

**Set Date:** A torpedo must pass through the opening for full points. The correct date is either when the first torpedo passes through the opening for the first half of the year, or the second torpedo passes through the opening for the second half of the year. Partial points may be awarded if the torpedo passes close to the cutout.

**Surface within the Octagon:** The sub must fully surface within the octagon to obtain full point value. If a sub surfaces in both correct octagons, points will be awarded for only a single correct octagon. Partial points may be awarded with judges' discretion. **If a sub surfaces within both octagons (when one is correct and one is incorrect), only points for “Surfacing within an Octagon” will be awarded.**

**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 be free to fall from the vehicle to obtain full points. The structure hanging on the vehicle may be awarded partial points with judges' discretion.

**Object on Railroad:** The object must be touching the black track to obtain any points. If aligned with the track, full points will be awarded.

**Railroad Track:** The DeLorean must be in front of the Train, and both must be on the tracks (proper orientation, close to the rails, etc.)

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

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

## 7. AWARDS

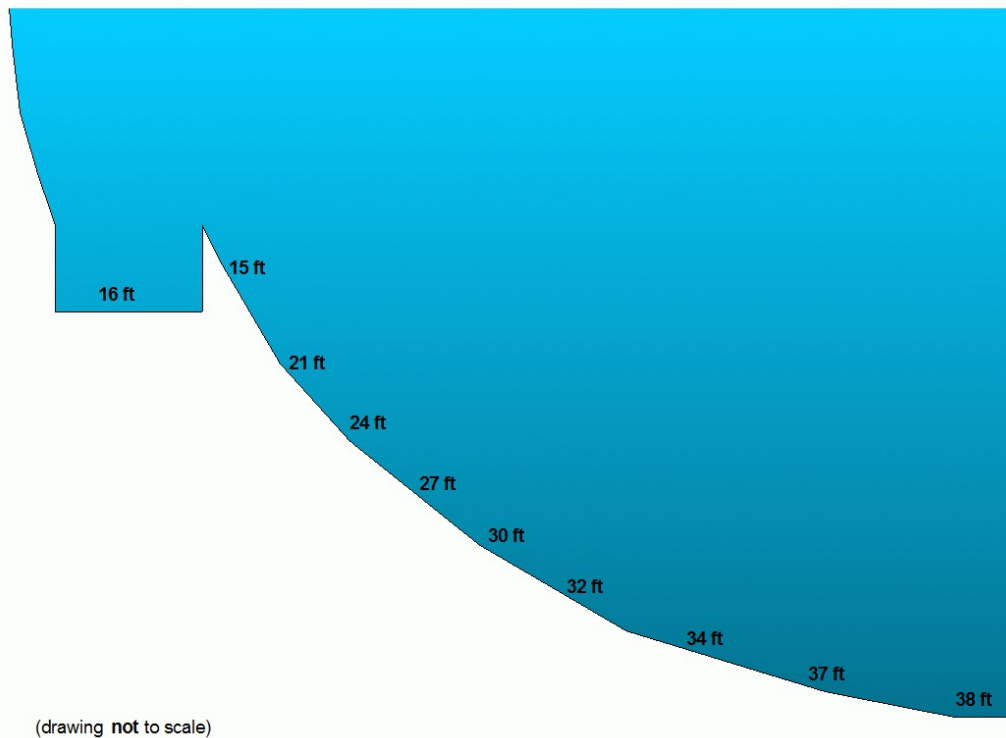
Cash prizes (and serious bragging rights) will be awarded at the discretion of the judges.



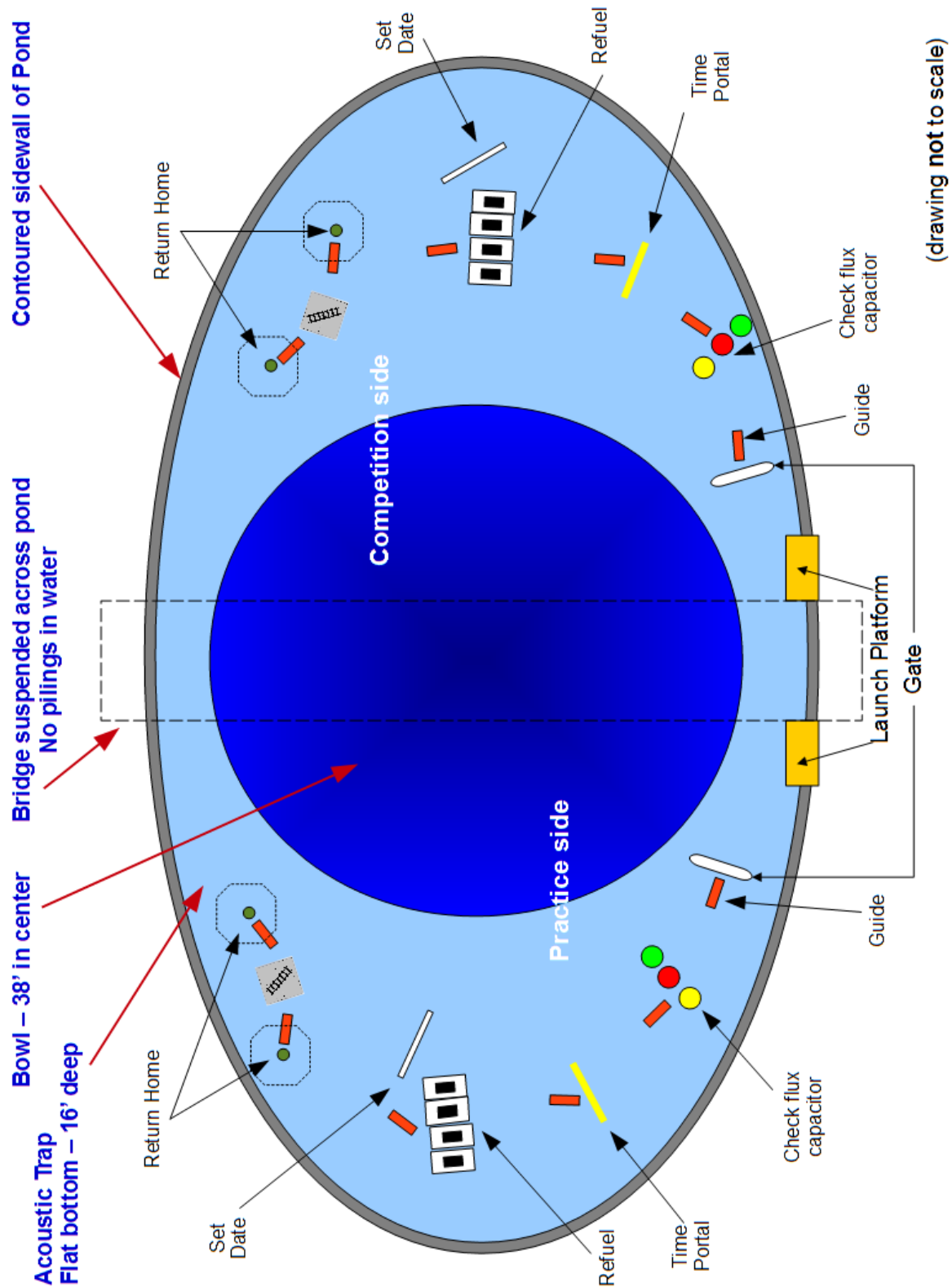
## 8. Diagrams



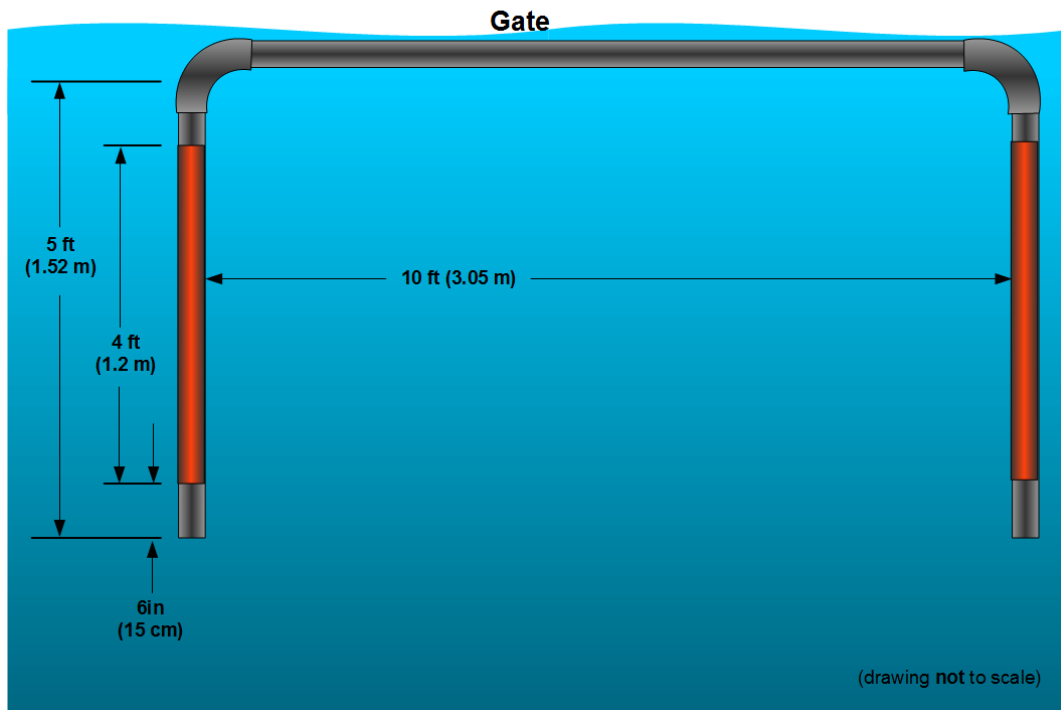
*Drawing 1: Aerial photo of facility. The bridge structure has no piers or supports in the pond.*



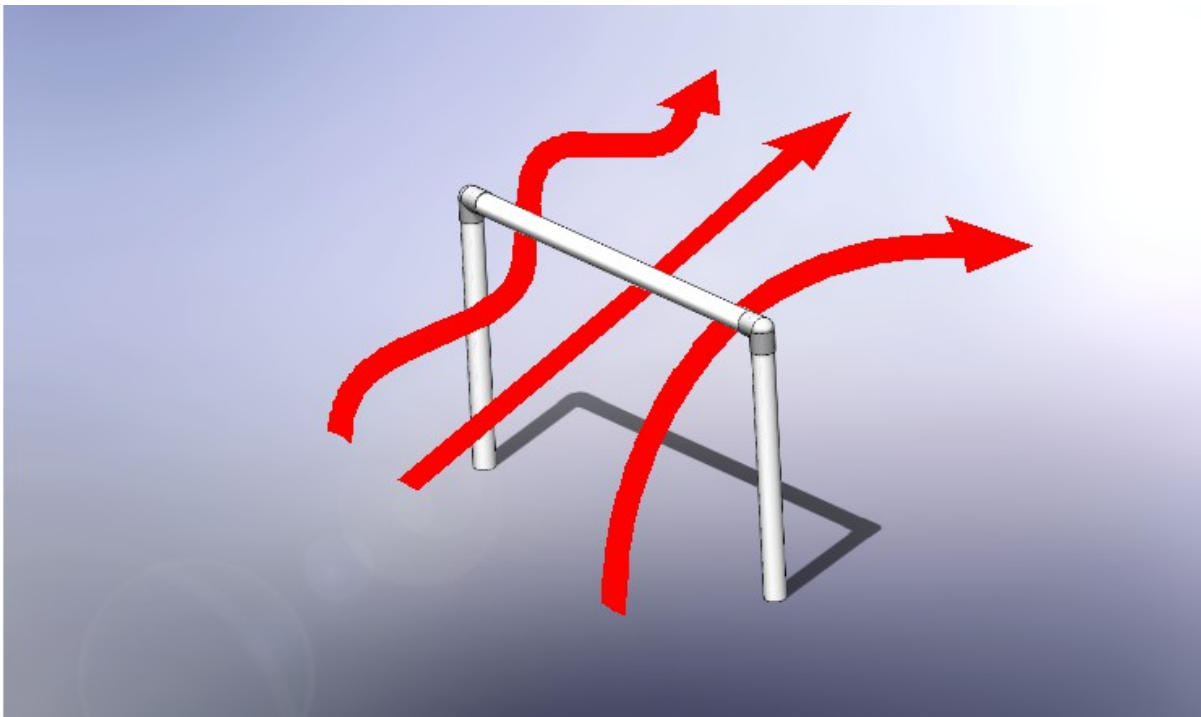
*Drawing 2: Cross section of arena showing the depth profile in feet. Note that the acoustic trap (the 16ft deep section around the perimeter) varies in width around the pond.*



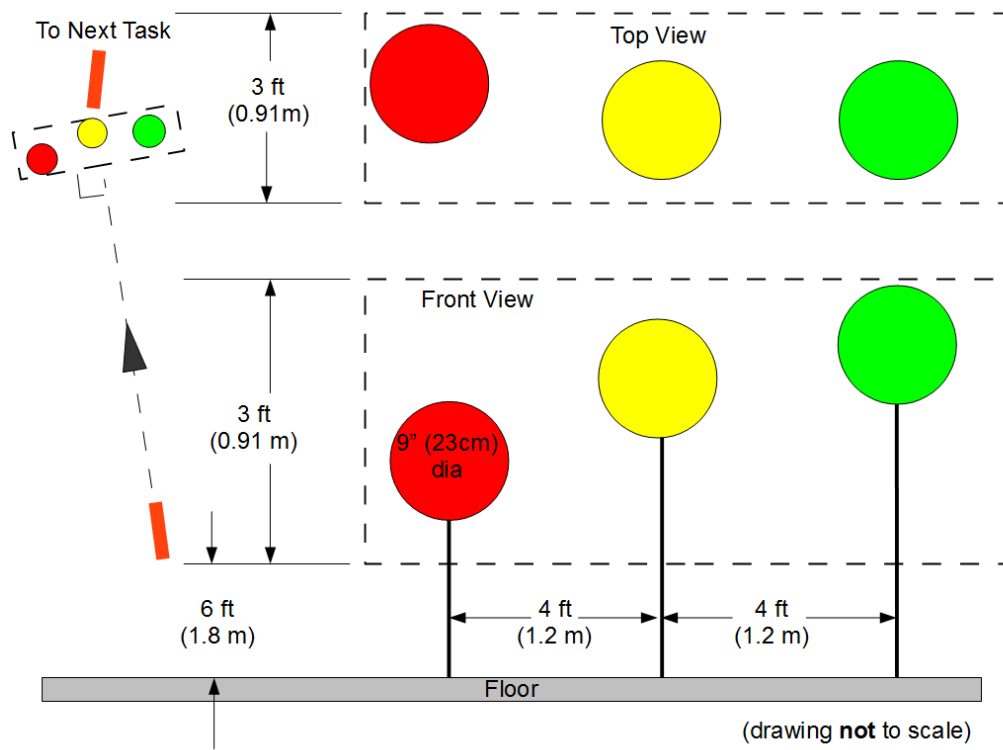
*Drawing 3: General layout of the arena. The arena is split into a competition side (right half of this view) and a practice side (left half).*



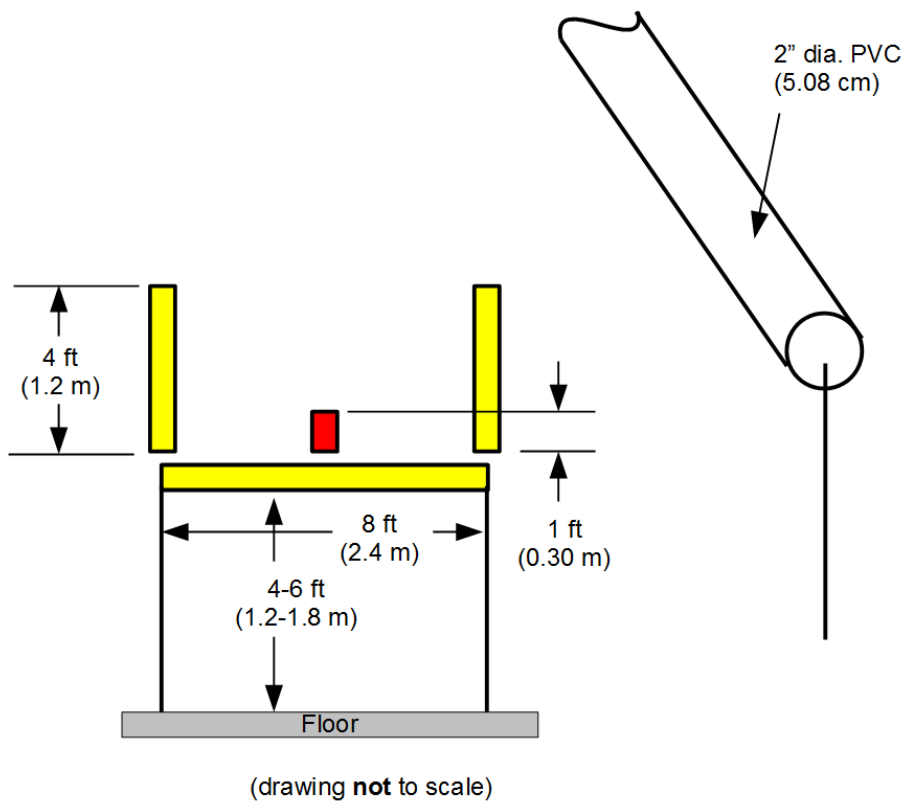
*Drawing 4: Validation gate. The gate is constructed of 3 inch diameter black PVC pipe. It will be buoyant, and will be moored to the bottom. The vertical legs will be masked with orange Duck tape.*



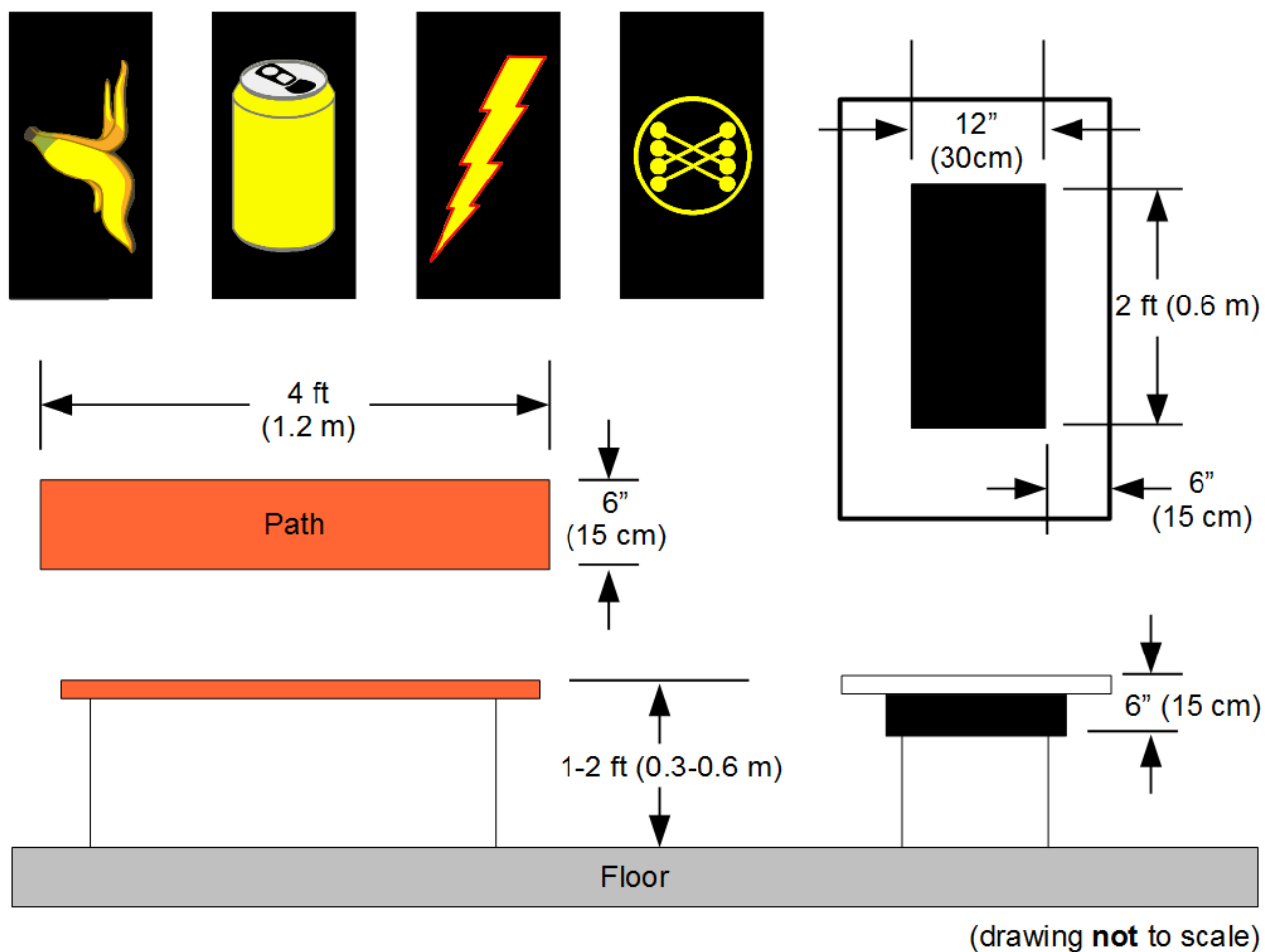
*Drawing 5: Valid ways to pass through the validation gate during the practice days.*



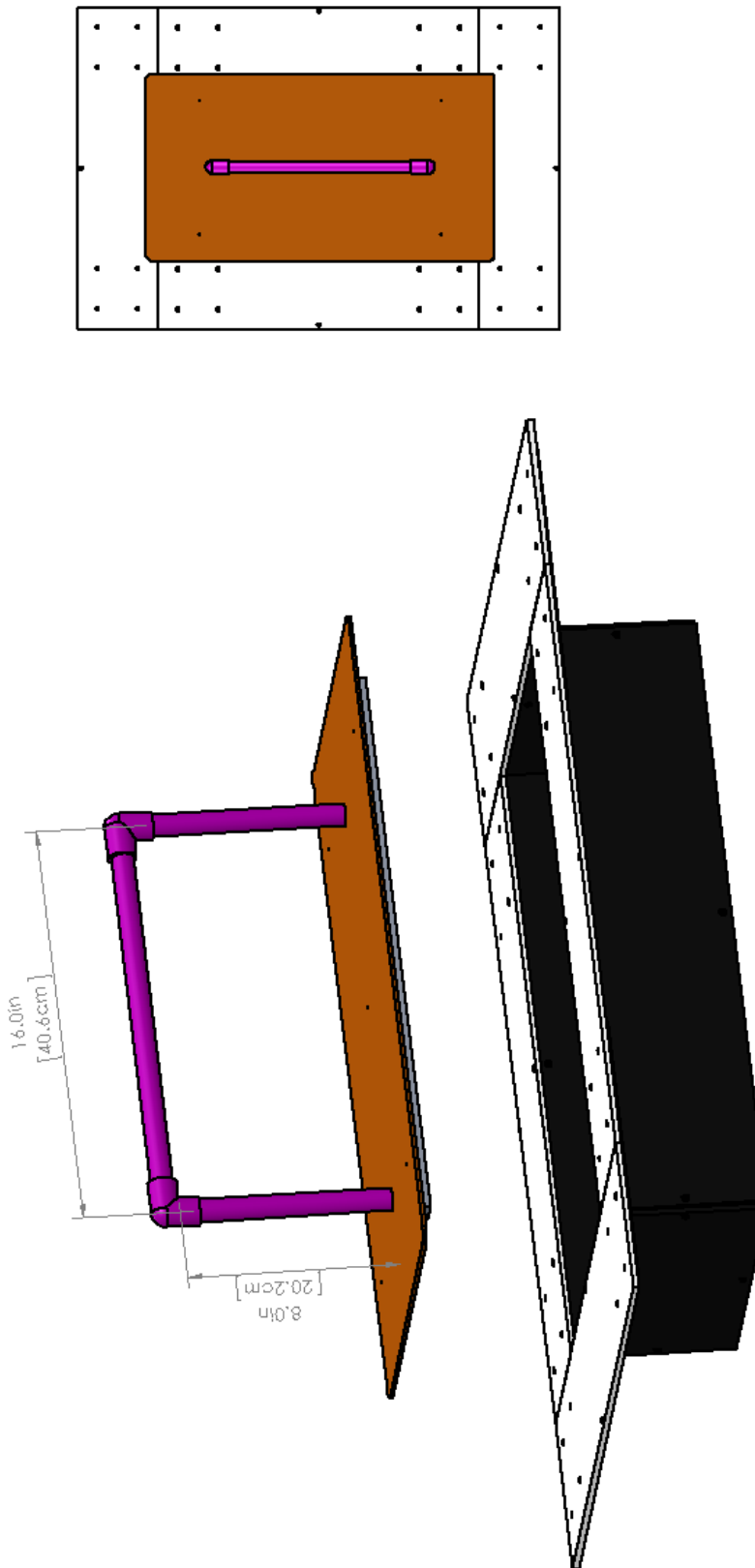
*Drawing 6: Check Flux Capacitor (buoy), mooring line and base.*



*Drawing 7: Time Portal (PVC pipe) and mooring lines*

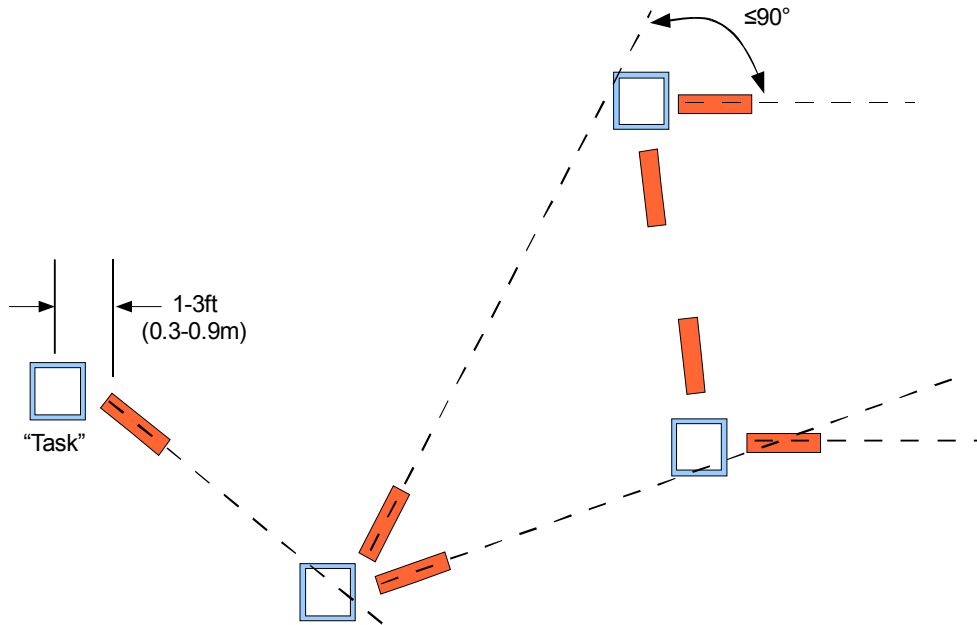


*Drawing 8: Guide and Refuel (target bins). Distance between the path segments will vary.*

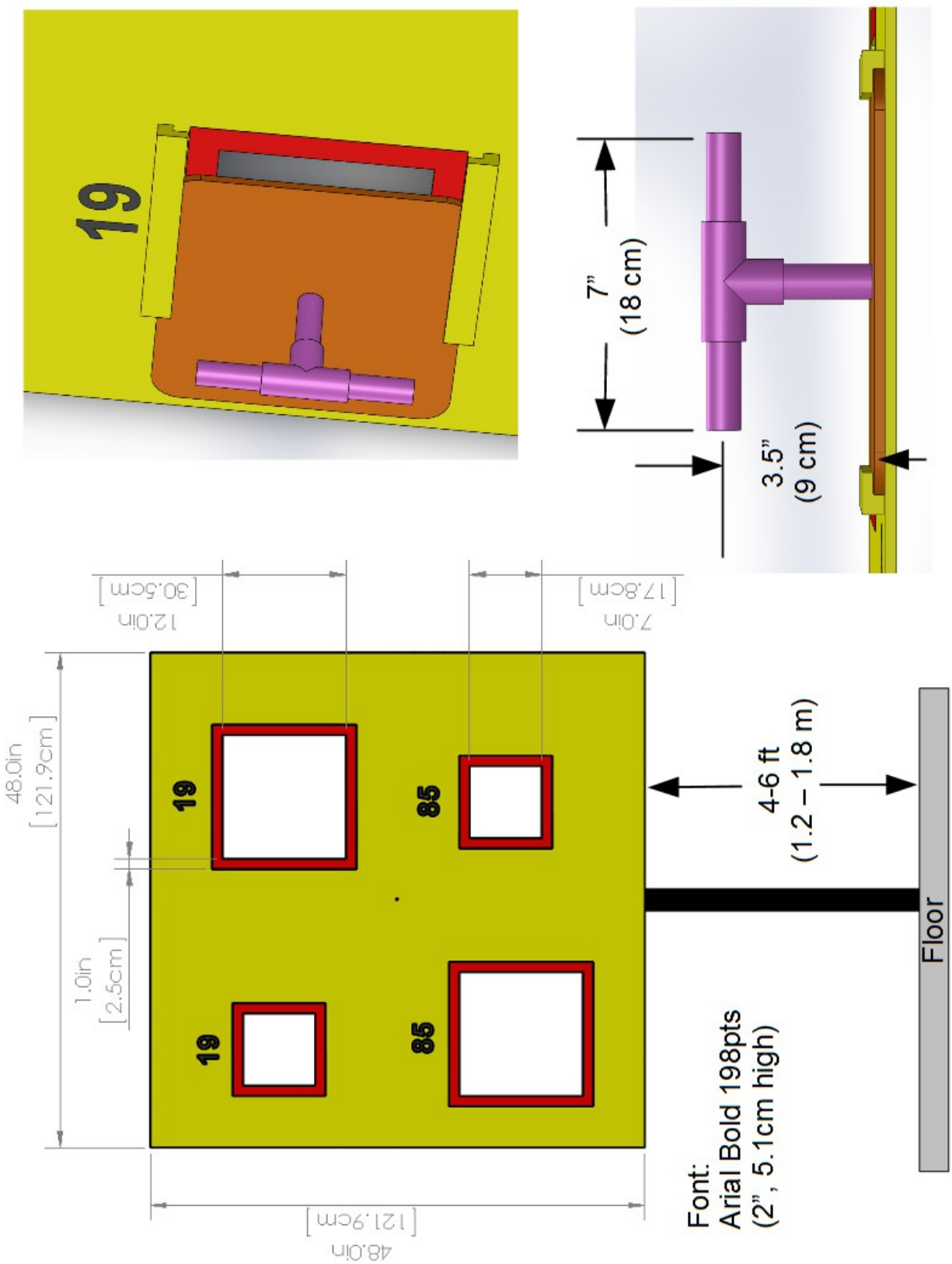


*Drawing 9: Refuel cover (target bins). Handle may be 1/2" PVC or 1/2" square dowels. Railings mounted on the underside prevent the lid from being slide off the bin.*

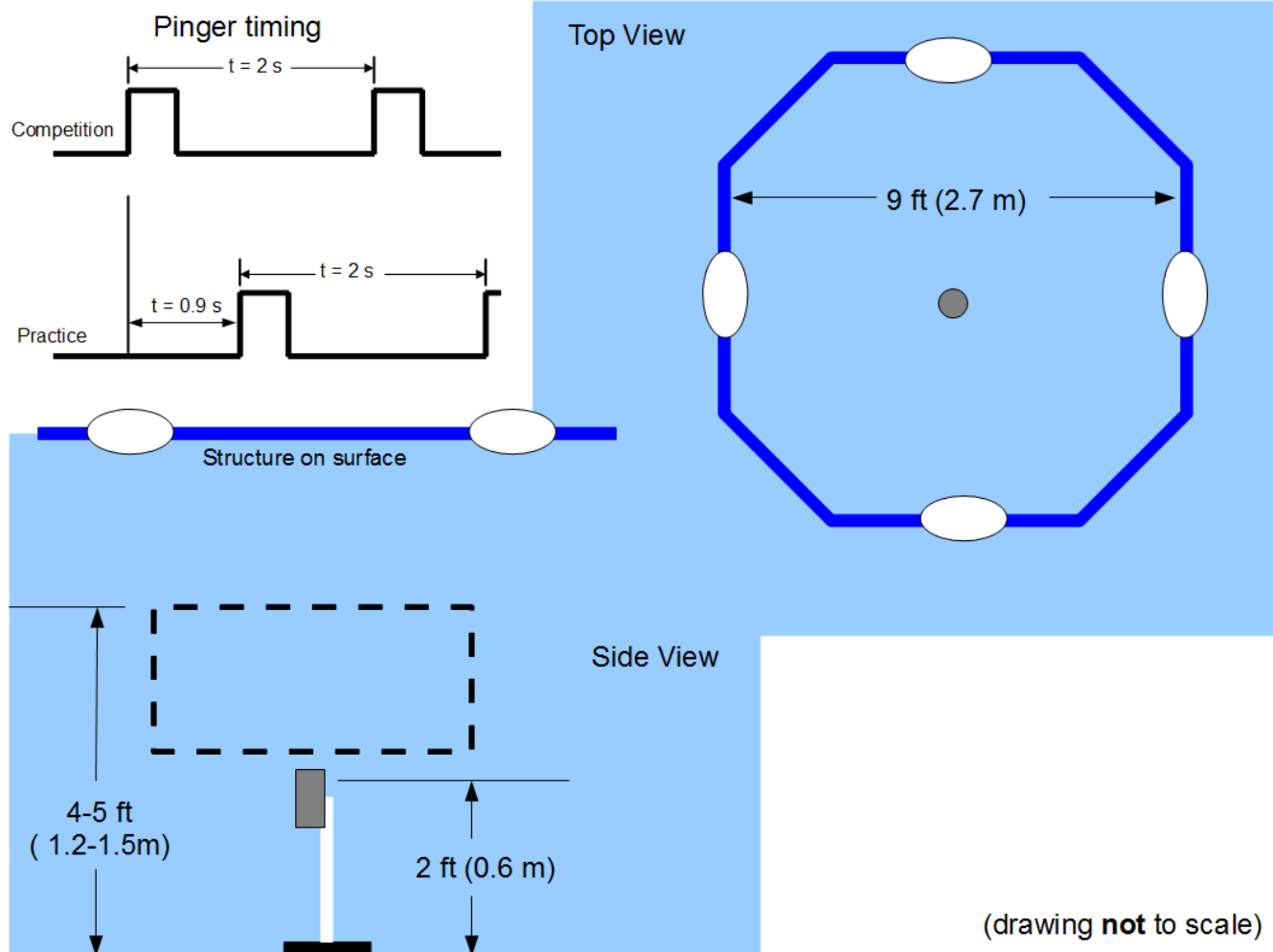




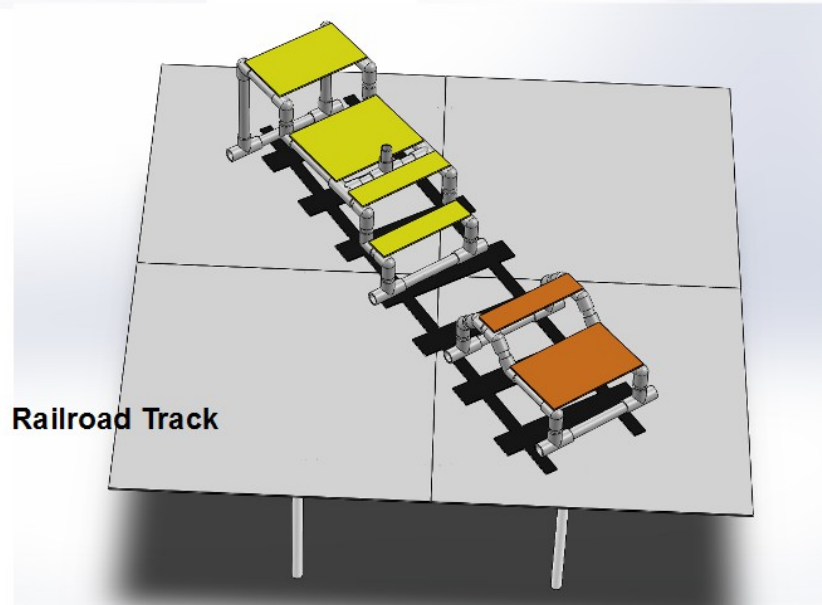
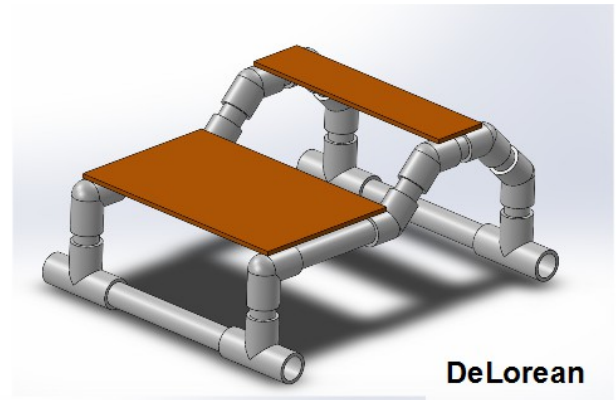
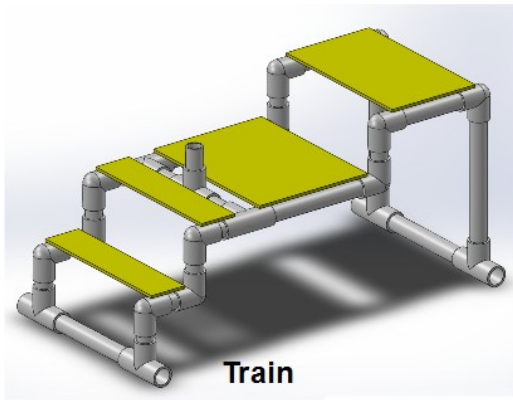
*Drawing 10: Expected distance and angles for the path segments*



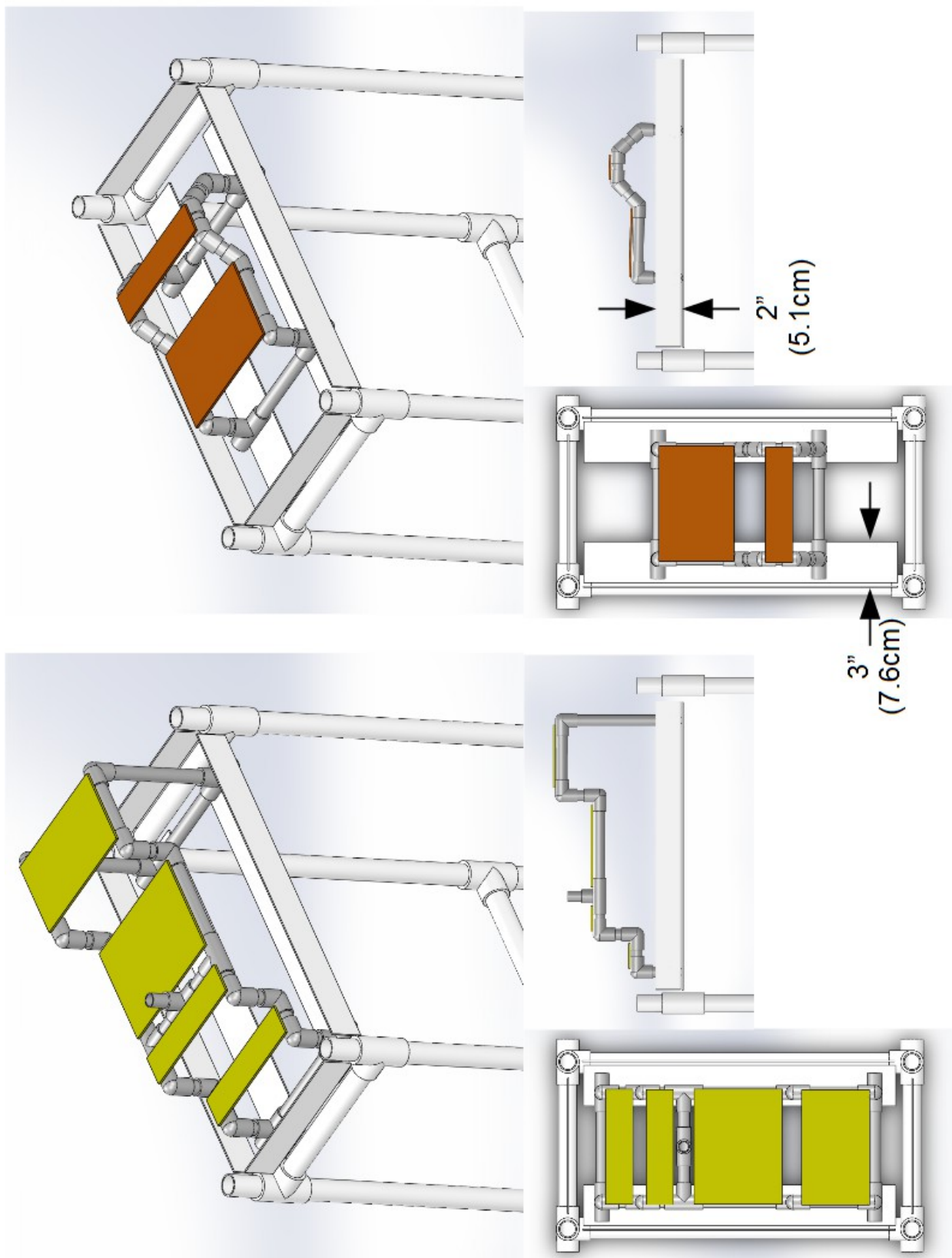
*Drawing 11: Set Date (Torpedo cutouts) and mounting. Handle may be made from 1/2" PVC or 1/2" square wooden dowel.*



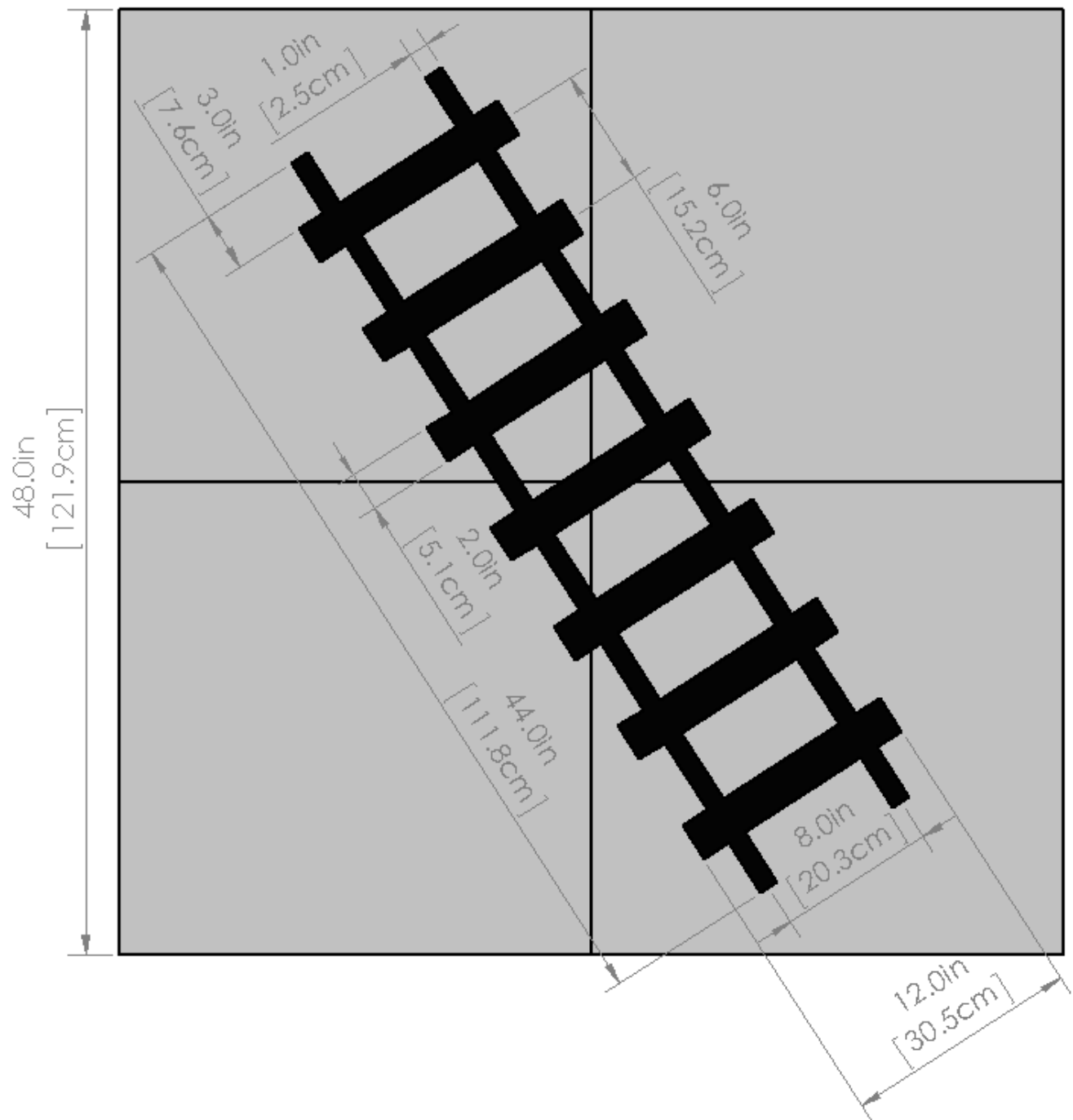
*Drawing 12: Return Home. The Area is marked on the surface with a floating 1/2" PVC pipe. The acoustic pinger is mounted on a pole in the center of this area. The Sample box is positioned directly above the pinger.*



*Drawing 13: Objects and Railroad track.*



*Drawing 14: Towers supporting DeLorean and Train.*



*Drawing 15: Dimensions of Railroad track.*