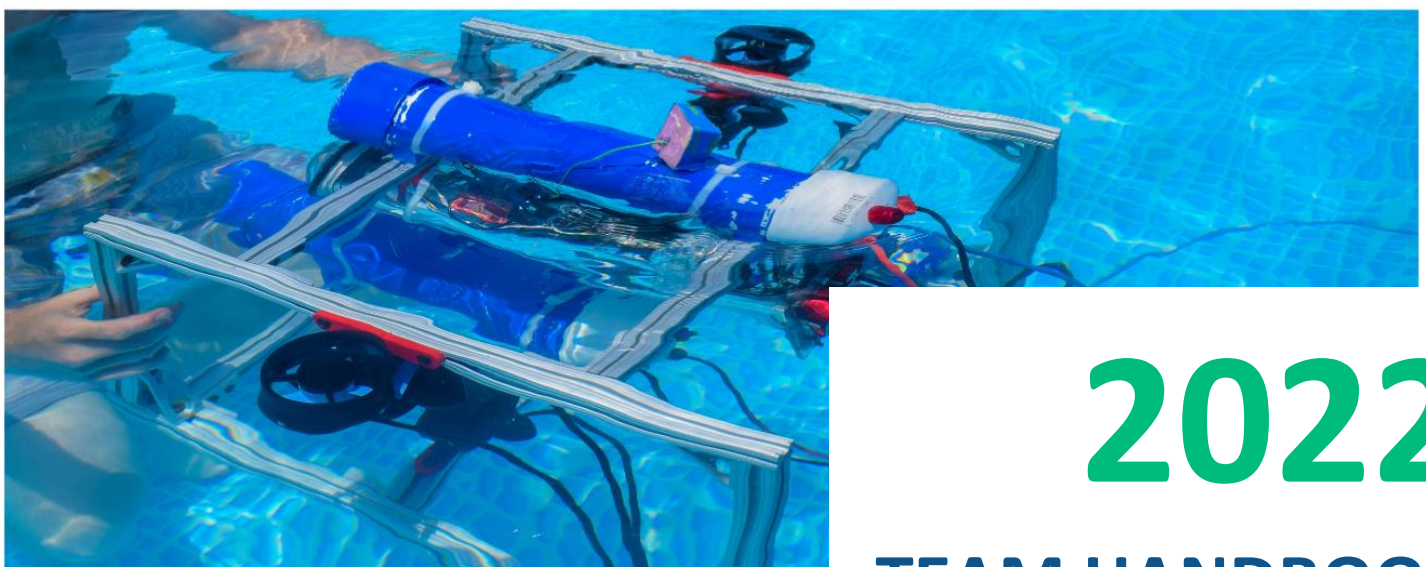




 **robosub**
Roarin' 20's



2022

TEAM HANDBOOK

Version 1 (January 2022)

Introduction

Welcome to the RoboSub Competition!

This Team Handbook contains information that teams need to compete at the RoboSub Competition. It includes task descriptions, rules, and requirements, and other guidance and specifications. Teams are encouraged to read this document for a thorough understanding of what is necessary to compete effectively.

Why compete in RoboSub? RoboSub is an international student program established to generate, cultivate, and enhance a community of innovators by challenging new generations of engineers. Student teams tackle fundamental challenges in the design of ocean systems, while getting hands-on experience by designing, building and testing a fully autonomous underwater vehicle (AUV). By providing a venue and mechanism to share knowledge and innovate, students are primed for jobs in developing, testing and managing state-of-the-art systems. Teams must also document their designs.

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 accomplished a challenging mission in a complex environment.

Why robotics competitions? The goals of the RoboNation student competitions are to provide opportunities for students to experience the challenges of system engineering, to develop skills in accomplishing realistic missions with autonomous vehicles, and to foster relationships between young engineers and the organizations developing and producing autonomous vehicle technologies. The objective is to produce the people who will push the envelope in the future. Competitors gain an appreciation for the tradeoffs inherent in any system design and the lessons learned in transitioning from a working bench prototype to operating reliably in the real world.

Maritime autonomous technology is critical to monitoring and healing our oceans. Developing the human resource to expand this effort is even more essential.

ROBOSUB ORGANIZERS



The RoboSub Competition is hosted by RoboNation.

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Version Updates

RoboSub 2022

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| Version | Changes | Date |
|---------|--|-----------------|
| V1 | First release of RoboSub 2022 Team Handbook. | 25 January 2022 |

Table 1. Document Version Log

SECTION 1: RoboSub Overview

*RoboSub 2022**www.robosub.org*

1.1 Dates & Venue

The 2022 RoboSub Competition (RoboSub 2022) will be conducted 25-31 July 2022 in California, USA. The venue is being finalized and will be released at a late date.

Health and Safety

Due to the evolving nature of COVID-19 related travel and tourism guidance, teams are encouraged to stay apprised of updated rules and regulations for entering the United States and California. For more information, see [Section 5: How to Compete](#).

1.2 Mission and Theme

The Roarin' 20's refers to the decade of the 1920s in Western society. Jazz blossomed, the flapper redefined the modern look for British and American women. This period saw the large-scale development and use of automobiles, telephones, films, radio and electrical appliances. The passage of the 18th amendment to the U.S. Constitution made it illegal to manufacture, import or sell beer, wine and hard liquor. The various restrictions were wildly unpopular leading to violations of the law, and the rapid rise of speakeasies and organized crime.

The fundamental goal of the mission is for an AUV to demonstrate its autonomy by interacting with various tasks. Orange guide markers help direct the AUV to the beginning tasks. Acoustic pingers guide the AUV to the remaining tasks. The AUV is able to interact with these tasks:

- *With Moxy* (Coin Flip)
- *Collecting* (Bins)
- *Survive the Shootout* (Torpedoes)
- *Choose Your Side* (Gate)
- *Make the Grade* (Buoys)
- *Cash or Smash* (Octagon)

1.3 Competition Structure

RoboSub includes Design Documentation and the Autonomy Challenge with the option for teams to compete in-person (travel to California, USA) or online (from home/school location). The Design Documentation presents each team's work and vehicle design. The Autonomy Challenge demonstrates safety and performance.

1.4 Eligibility

Student teams from anywhere in the world are eligible to participate.

1.4.1 Eligibility Details & Team Composition

- Teams must be comprised of 75% or more full-time students. Student members are expected to make significant contributions to the engineering development cycle of their AUV.
- The majority of team members must be college or high school students. Teams may also include middle school students. Interdisciplinary teams are encouraged.
- Teams may be comprised of 25% or less alumni, industry, academic or government partners.

1.5 Point of Contacts

RoboSub Questions:
autonomy@robonation.org

Registration Questions:
support@robonation.org

Technical Questions:
robosub.org/forum

On-Site Logistics/Safety:
events@robonation.org
850.642.0536

SECTION 2: Competition

*RoboSub 2022**www.robosub.org*

This section includes general competition information for RoboSub 2022 including competition schedule, Design Documentation, and Autonomy Challenge.

2.1 Competition Schedule

The competition includes:

- **Design Documentation:** Teams present a variety of design documentation prior to and during the competition.
- **Autonomy Challenge:**
 - **Qualifying Round:** Teams assemble and test their AUV, participate in initial safety inspections, practice, and qualify for Semi-Finals in the water on one of the courses.
 - **Semi-Finals Round:** Teams complete runs on the Semi-Finals Courses to qualify for the Finals Round.
 - **Finals Round:** Teams complete runs on the Finals Course.

| Date | Event | Location |
|--------------|--|-----------------|
| June-July | Design Documentation (prior to on-site competition) | Online |
| 25 July | Team Orientation | To Be Announced |
| 26 - 28 July | Vehicle Assembly + Safety Inspections Qualifying and Practice Course Open | |
| 29 - 30 July | Semi-Finals Round Design Presentations | |
| 31 July | Finals Round Awards | |

Table 2. RoboSub Schedule

2.2 Design Documentation

Prior to the on-site competition, teams provide a variety of design documentation. During the competition, teams provide an oral presentation and their AUV is assessed by subject matter expert judges.

2.2.1 Delivered Prior to On-Site Competition

The following design documentation is delivered prior to the on-site competition. How to submit deliverables can be found in Section 5.2 Pre-Competition Requirements.

Team Website

Teams are required to submit a website in English that documents their team, vehicle design, and competition approach, addressing the following areas:

1) Website Content: Layout and detailed contents of the website are left for the teams to develop; however, the team website should include:

- Team name and contact information
- Team name, picture and contact information for each contributing member
- Vehicle diagrams
- Instructional/Informative videos
- Procedures (text, images)
- Design decision documentation (text, images, videos)
- Blogs for historical records of build progress
- List of sponsors with logos

2) Website Quality: Websites are often the first impression of a project. Potential supporters such as supervisors, sponsors, or advisors must find the website visually appealing and easy to navigate.

Development of the website should include careful consideration of user experience, including:

1. Written in English, or English translation provided
2. Clear prioritization of key content
3. Site search functionality
4. Basic design elements: contrast, repetition, alignment and grouping to organize/highlight content
5. User accessibility, as defined by the W3C Web Accessibility Initiative: www.w3.org/WAI
6. Cross browser compatibility for modern web browsers (Chrome, Firefox, Safari, MS Edge)
7. A mobile friendly display

Technical Design Report

Teams are required to submit a technical design report in English that describes the design of their AUV autonomy systems, propulsion system, and control systems, as well as strategies for their approach to the tasks. This paper should include the rationale for their design choices. Guidelines for this report are available in Appendix A: Technical Design Report.

Competition Strategy Video

Teams are required to create a video outlining their competition strategy. This includes an introduction, the tasks they plan to attempt, and their approach to complete each task.

Format Requirements:

1. Teams must abide by all applicable social distancing protocols.
2. Video must be conducted in English or include subtitles in English.
3. Video must be no more than eight (8) minutes in length.
4. Videos must be hosted by team:

OPTION 1: Hosted on team's YouTube Channel.

- Videos shared on the [RoboNation YouTube Channel](#).
- Must follow [YouTube Rules & Policies](#), including appropriate music copyright management.

OPTION 2: Host/Embed on Team Website.

2.2.2 Delivered During On-Site Competition

Design Presentation

Teams give a design presentation to a panel of judges. Each team must present their competition strategy and how that plan impacted their design and selections. This oral presentation must be conducted in English and may include visual aids. This presentation includes:

- Team presentation
- Judges' question and answer
- Judges' inspection of vehicle

Presentations are conducted either in-person or online, dependent on venue selection.

2.3 Autonomy Challenge

These challenges showcase AUV performance through autonomous behaviors designed to represent research and real-world applications. Teams have the option to conduct the Autonomy Challenge with a live demonstration in-person (travel to California, USA) or a video demonstration online (from home/school location).

2.3.1 Live Demonstration (In-Person Teams)

Teams who can travel to the competition site showcase their vehicle performance through autonomous completion of a range of tasks on-site at the competition site.

Mandatory Activities

Prior to entering any of the Autonomy Challenge courses, teams are required to demonstrate their ability to safely operate their AUV.

Qualifying Round

Multiple courses are available for teams to practice, demonstrate proficiency, and qualify for the Semi-Finals Round. Each course includes all tasks. Teams may schedule times to practice or qualify on these courses. ([Section 2.6 Autonomy Challenge Sequence of Events](#))

Semi-Finals Round

Teams that qualify for the Semi-Finals gain access to the Semi-Finals Courses. Teams operating on the Semi-Finals Courses may earn points towards entry into the Finals Round. During the Semi-Finals Round, teams may attempt tasks in any order and must operate autonomously for the entire run. ([Section 2.6 Autonomy Challenge Sequence of Events](#))

Finals Round

During the Finals Round, successful completion of the full Finals Course requires the AUV to use information from multiple task elements. During the Finals, teams may attempt tasks in any order and must operate autonomously for the entire run. ([Section 2.6 Autonomy Challenge Sequence of Events](#))

2.3.2 Video Demonstration (Online Teams)

Teams who cannot travel to the competition site showcase their vehicle performance through a video demonstration. The video is not scored; however, the video is published online on the [RoboNation YouTube Channel](#) and can be eligible for special awards and recognition.

2.4 Mandatory Activities

2.4.1 Live Demonstration (In-Person Teams)

In-Person teams showcase their vehicle performance through a live demonstration of autonomous completion of a range of tasks on-site at the competition site. Prior to entering any of the Autonomy Challenge courses, teams must demonstrate their ability to safely control their AUV.

Static Safety Inspection

Prior to deploying in the water, the AUV must meet all safety requirements. At a minimum, the following areas are checked:

- Emergency Stop System (location of switches, on-board and remote functionality)
- Safety issues related to propellers or hazards
- All systems are properly secured

Each vehicle is physically inspected by the Technical Director (TD) team. The TD team may disqualify any vehicle that they deem to pose an unreasonable safety hazard to the host facility. More details on system requirements are available in [Section 4.3.1 AUV Requirements](#).

Weight Measurement

Vehicles are weighed before each semi-finals and finals run. Vehicles 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 3 shows the bonuses and penalties associated with a vehicle’s weight in air.

| | 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 $250 + 5 \cdot (\text{lb} - 125)$ $250 + 11 \cdot (\text{kg} - 56.7)$ |
| 84 lbs ≥ AUV Weight > 48.5 (38 kg ≥ AUV Weight > 22) | Bonus of $2 \cdot (84 - \text{lb})$ $4.4 \cdot (38 - \text{kg})$ | N/A |
| AUV Weight ≤ 48.5 lbs (AUV Weight ≤ 22kg) | Bonus of $80 + (48.5 - \text{lb})$ $80 + 2.2 \cdot (22 - \text{kg})$ | N/A |

Table 3: Vehicle weight in air with Bonus or Penalties

2.4.2 Video Demonstration (Online Teams)

Online teams showcase their vehicle performance through a video demonstration of autonomous completion of a range of behaviors. This video is not scored; however, the videos are shared online on the [RoboNation YouTube Channel](#).

Teams must choose at least one (1) behavior to demonstrate. Teams may use creativity to build something similar to the published course elements in [2.5 Task Descriptions](#). If teams do not have access to water, the vehicle behaviors can be demonstrated in a simulation environment.

Vehicle Behaviors

The behaviors are listed in rank order of difficulty, 1-5.

1. Maintain heading and depth: Submerge and transit while maintaining heading and depth
2. Attitude control: Controlled rotation around the three different axes
3. Navigation: Visually identify and navigate toward or via a target
4. Marker/Torpedo: Show marker drop or torpedo launcher
5. Two step behaviors
 - a) Visual ID + manipulation: Clearly show the vehicle identifying an object and transiting toward object and exhibiting additional behavior such as picking up or dropping off
 - b) Acoustic ID + manipulation: Show vehicle using an acoustic pinger to navigate toward a target and perform additional behaviors such as launching a projectile, dropping an object or surfacing

Video Guidelines

An individual video should be submitted for each behavior attempted. Teams must include the following sections in each video:

- Introduction: Identify the school/team name and the behavior(s) demonstrated.
- Behavior Demonstration: Clearly show each behavior on video; this may include different angles. Each behavior may take up to 2 minutes of the video.
- Behavior Summary: Summarize each attempted behavior and a brief assessment of success.
- Closing: Provide brief closing statement for viewers; this may include acknowledgements.

Format Requirements

1. Teams must abide by all applicable social distancing protocols.
2. Video must be conducted in English or include subtitles in English.
3. Individual videos must be no more than five (5) minutes in length.
4. Video must include text or icon in upper left corner of screen indicating the vehicle is operating in autonomous mode.
5. Video must include text in upper right corner of screen indicating which behavior is being demonstrated.
6. Videos must be hosted by team:
 - OPTION 1: Hosted on team's YouTube Channel.
 - Videos shared on the [RoboNation YouTube Channel](#).
 - Must follow [YouTube Rules & Policies](#), including appropriate music copyright management.
 - OPTION 2: Host/Embed on Team Website.

2.5 Task Descriptions

This section provides details of the RoboSub Autonomy Challenge tasks. Teams are encouraged to develop a strategy approaching these tasks that best suits their AUV. The launch point, gate, or any of the tasks are placed such that no three elements are along a line.

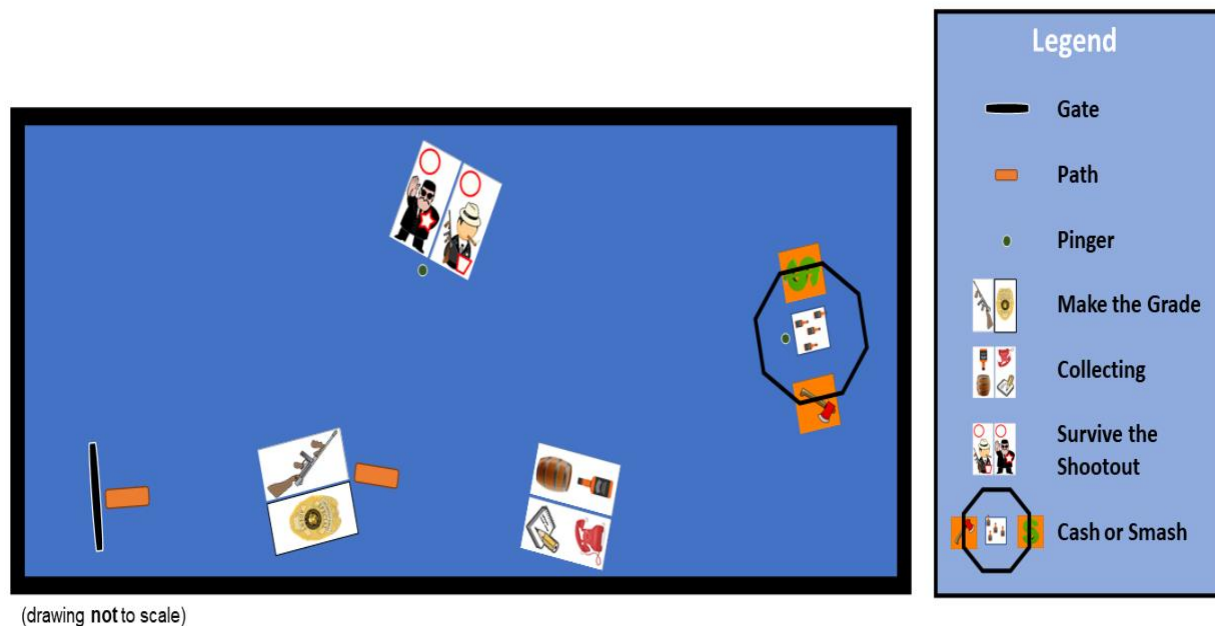


Figure 1: RoboSub course layout

2.5.1 With Moxy—Coin Flip

From behind the front of the starting dock, a team may point their AUV in any direction. Before the start of a run, and for additional points, teams may request a coin flip which determines the heading of the AUV for the start. If the coin lands on **Heads**, the AUV is parallel to the dock and points away from the gate. If the coin lands on **Tails**, the AUV is parallel to the dock and points away from the gate.

New: When starting a run, the AUV must *submerge* first and then either head toward the gate, or rotate to align with the gate and then head toward the gate. AUVs that do not submerge first do not receive the extra points.

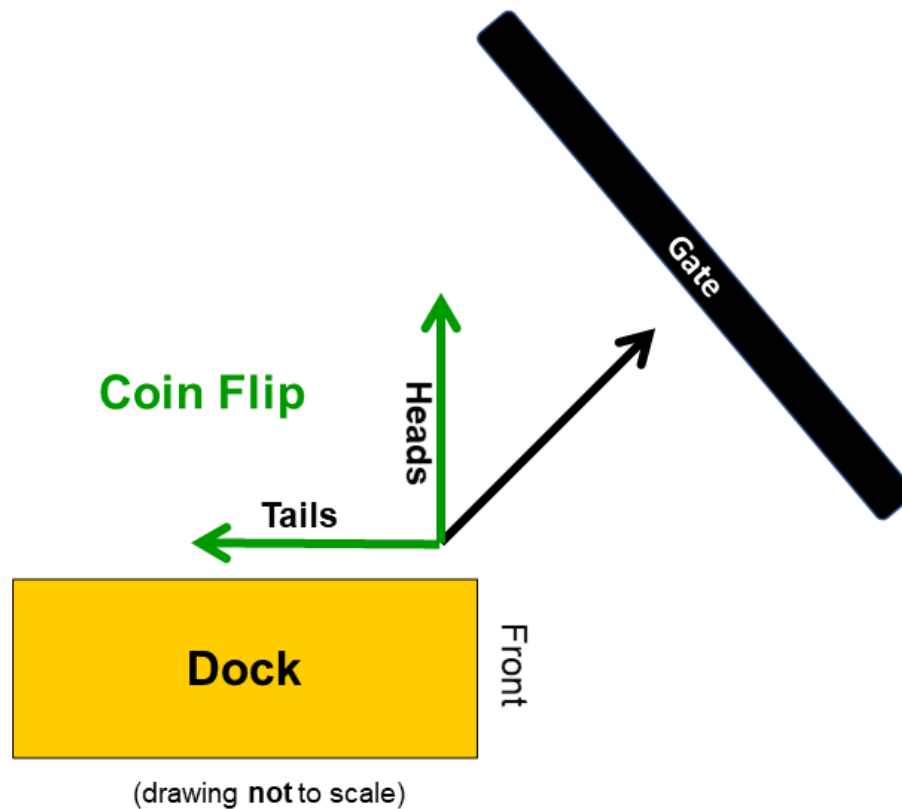


Figure 2: With Moxy

2.5.2 Choose Your Side—Gate

The validation gate is made from 3-inch black PVC pipe. It is buoyant, floating just below the surface and moored to the bottom. The vertical legs are colored **ORANGE**. The AUV 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 in half. G-man on one side, Bootlegger on the other. The AUV chooses a role by passing under either side.

Style points are extra points that can be gained by passing through the gate with “style”. For every 90° change in orientation, the AUV increases the multiplier, up to 8x. However, returning to the last previous orientation won’t count. I.e. an AUV that rolls 90° (+1 multiplier) and then back to 0° would not get +2 multiplier (remains on +1).

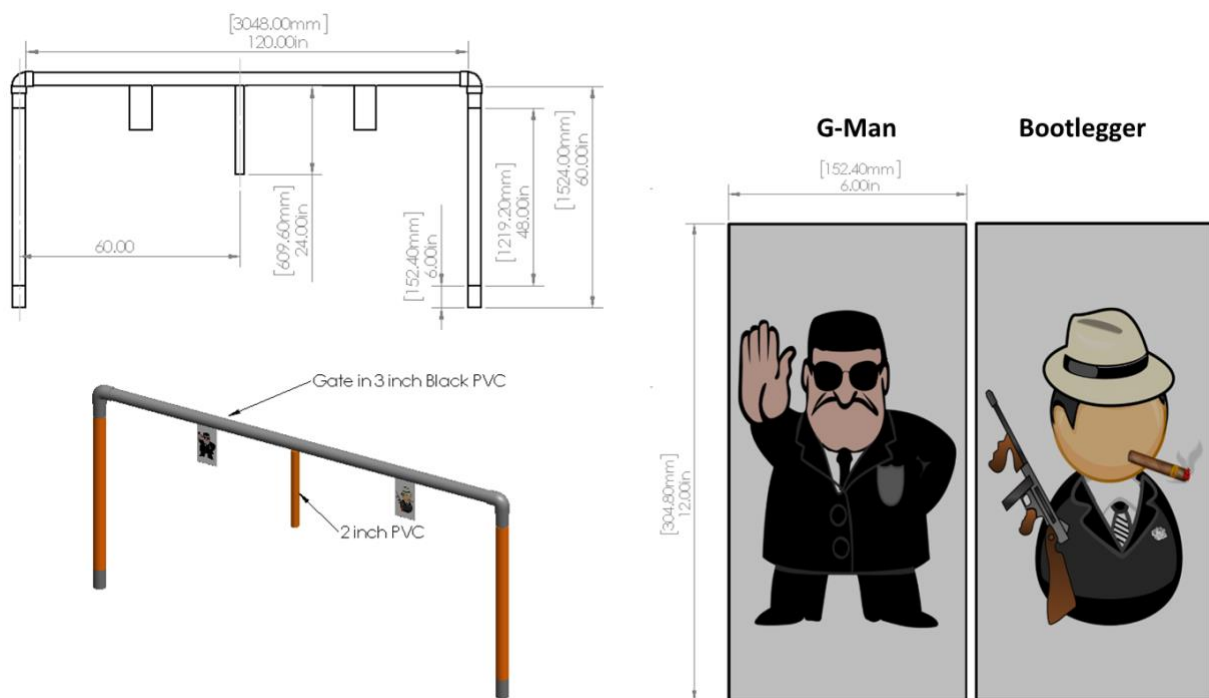


Figure 3: Choose Your Side

| Task Element | Description | Color | Base Dimensions |
|------------------|----------------------|----------------|------------------|
| Gate | 3 in. Black PVC Pipe | Black / Orange | 120 in. x 60 in. |
| Gate Divider | 2 in. PVC Pipe | Orange | 24 in. |
| Bootlegger Image | Image of Bootlegger | Vinyl print | 6 in. x 12 in. |
| G-man Image | Image of G-man | Vinyl print | 6 in. X 12 in. |

2.5.3 Path

The path markers are ~4 feet (~1.2m) long by 6 inches (15cm) wide. The path is colored **ORANGE**. Each path marker is placed directly after the current task and point to the next task. The path is a straight segment. No points are awarded for following the path, the path is intended to help guide the AUV to the next task.

There are two path markers to aid in navigation. One path marker is positioned at the gate that points to the *Make the Grade* (buoy) task. From *Make the Grade*, the second path points to *Collecting* (bins). Those are the only path segments which can be used to visually orient the AUV to the next task.

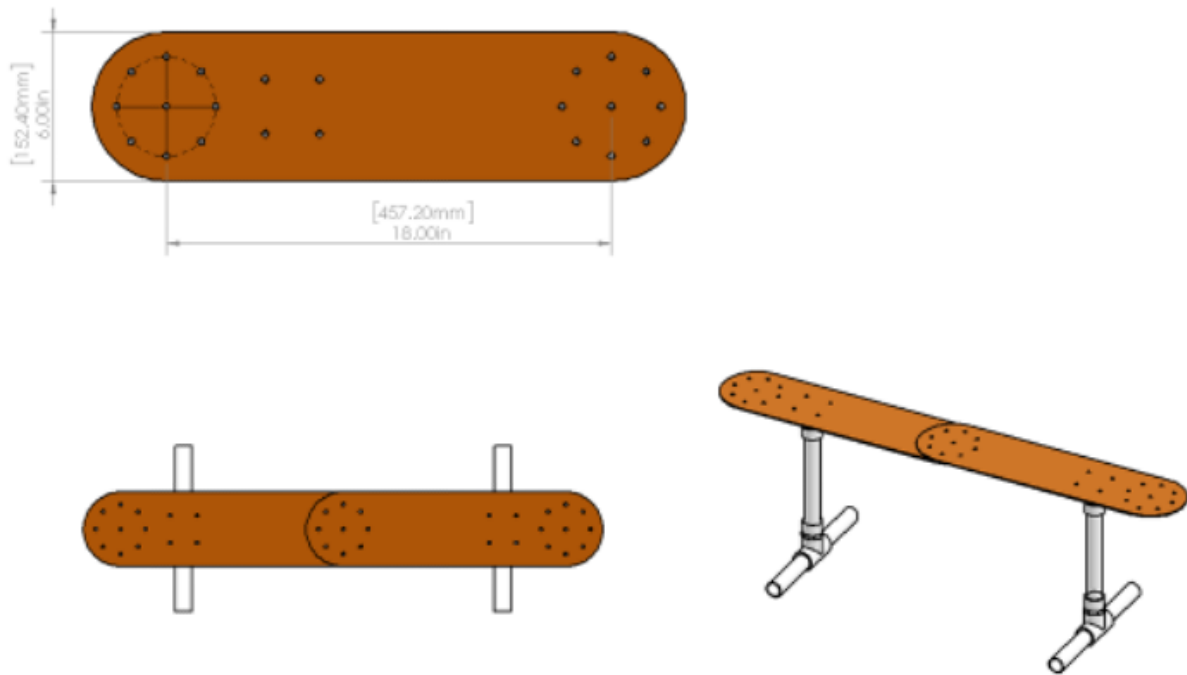


Figure 4: Path markers

| Task Element | Description | Color | Base Dimensions |
|--------------|----------------------------|--------|-----------------|
| Path Markers | Orange plates on PVC stand | Orange | 24 in. x 6 in. |

2.5.4 Make the Grade—Buoys

There are two “buoys” that are moored to the floor by line in two places. One buoy has the image of a Badge (G-Man) on both sides, and one buoy has the image of a tommy gun (Bootlegger).

Points are awarded for touching any buoy. More points are awarded for bumping the appropriate buoy for the side the AUV chose, based on *Choose Your Side* (Gate).

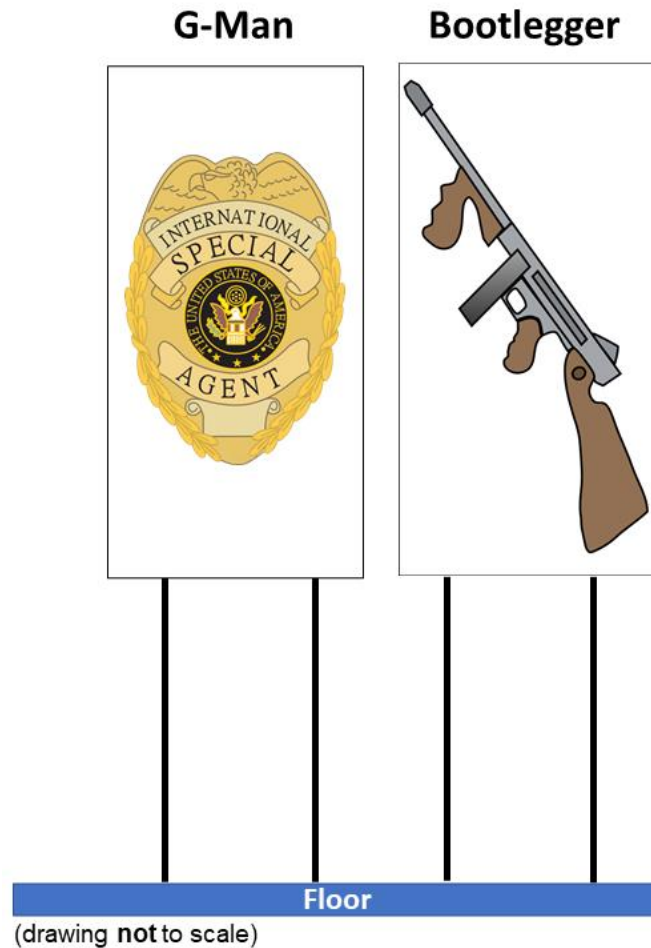


Figure 5: Make the Grade

| Task Element | Description | Base Dimensions |
|-----------------|-----------------|-----------------|
| Bootlegger Buoy | Tommy Gun image | 48 in. x 24 in. |
| G-man Buoy | Badge image | 48 in. x 24 in. |

2.5.5 Collecting—Bins

This task consists of two bins. In one bin, there is an image of a whisky bottle and barrel (Bootlegger: Collecting Spirits), in the other bin, there is an image of a phone and note pad (G-Man: Collecting Information). 1/3 of each bin is covered.

Points are awarded for dropping markers into either bin. Points are awarded for lifting off the cover. More points are awarded for dropping markers in the appropriate bin for the side the AUV chose, based on *Choose Your Side* (Gate).

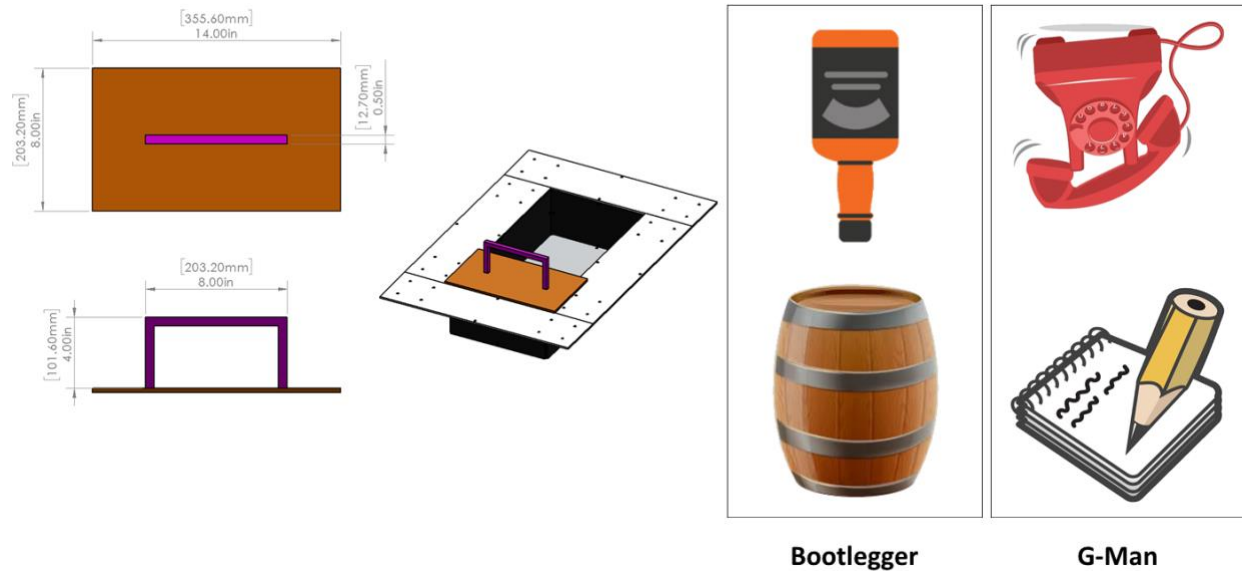


Figure 6: Collecting

| Task Element | Description | Base Dimensions |
|----------------|--|------------------------|
| Bootlegger Bin | Bin with Whisky bottle and barrel images | 24in. x 12 in. X 6 in. |
| G-man Bin | Bin with Phone and note pad images | 24in. x 12 in. X 6 in. |
| Cover/Handle | Cover and handle to lift off | 8 in. x 14 in. |

2.5.6 Survive the Shootout—Torpedoes

This task consists of two vertical boards with an image on each of the front sides. One is the image of the G-Man, and the other is the image of the Bootlegger (the same images from *Choose Your Side*). There is one small (Star, Shot glass) and one large opening (circle).

Points are awarded for firing torpedoes through the large opening. More points are awarded for firing torpedoes through the small opening. Maximum points are awarded for firing torpedoes through the small opening on the appropriate side. G-Men fire through the bootlegger image and Bootleggers fire through the G-Man image.

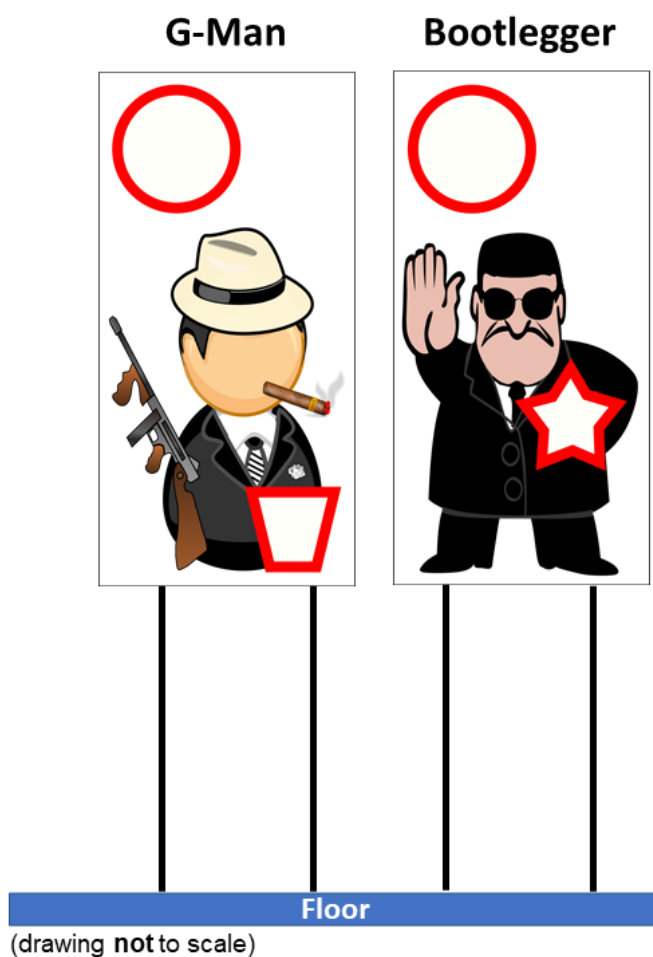


Figure 7: Survive the Shootout

| Task Element | Description | Base Dimensions |
|-----------------|------------------|-----------------|
| Bootlegger Buoy | G-Man image | 48 in. x 24 in. |
| G-man Buoy | Bootlegger image | 48 in. x 24 in. |

2.5.7 Cash or Smash—Octagon

A 9 ft (2.7m) diameter octagon floats on the surface and an acoustic pinger, located on the floor at the center of the octagon, guides the AUV to this task. Located in the center of the octagon, on a platform, is a collection of four “bottles” (PVC structure). On one side of the octagon is a table with a dollar sign (Bootlegger), on the opposite side of the octagon is a table with an axe (G-Man).

Points are awarded for surfacing inside the octagon and for surfacing with each bottle (inside the octagon). Points are awarded for moving the bottle to one of the tables. Maximum points are awarded for placing the bottles on the appropriate table.

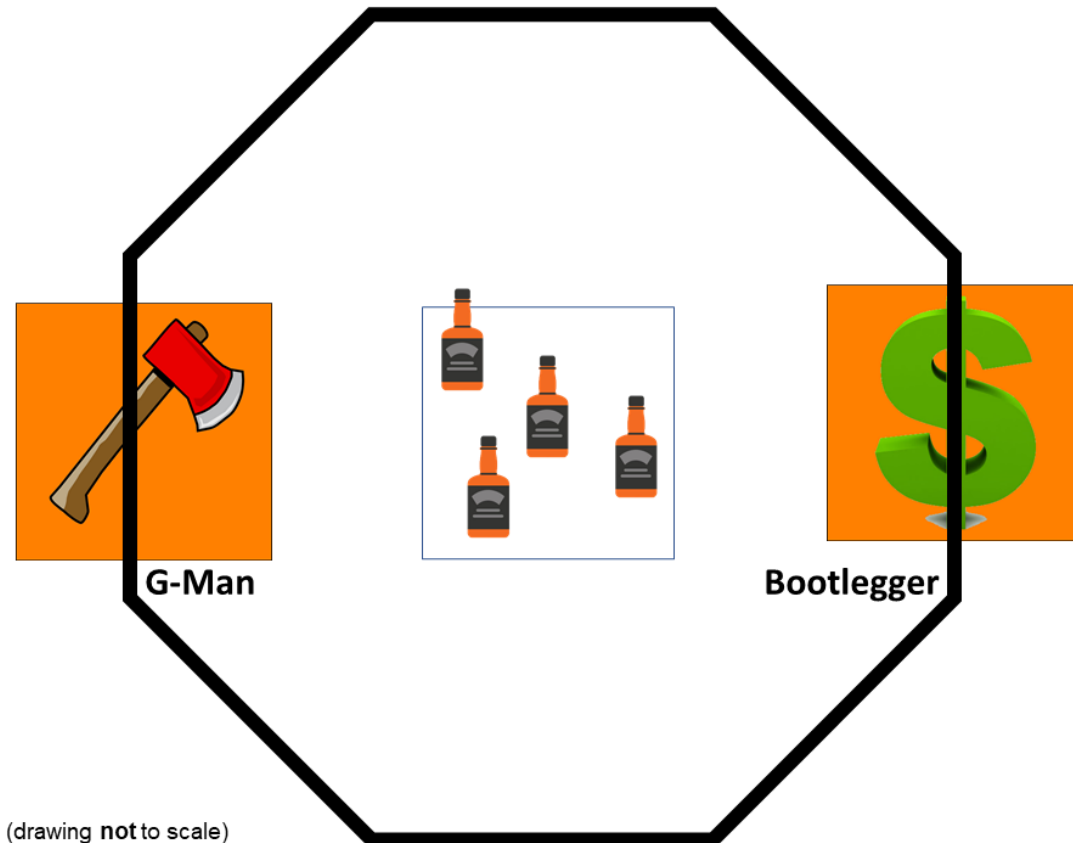


Figure 8: Cash or Smash

| Task Element | Description | Base Dimensions |
|-------------------------|--------------------------------------|-----------------|
| Octagon | Surface marker | 9 ft. diameter |
| G-Man table | Bottle placement for G-Man side | 2 ft. X 2 ft. |
| Bootlegger table | Bottle placement for Bootlegger side | 2 ft. X 2 ft. |
| Bottle table | Starting location for bottles | 2 ft. X 2 ft. |
| Bottle | Item to be picked up and moved | TBD |

2.6 Autonomy Challenge Sequence of Events (In-Person Teams)

The on-site competition allows for days of practice, qualifying, semi-final, and finals runs for the Autonomy Challenge. This section outlines what teams can do before arriving at the competition and what to expect during competition days.

The sequence of events for in person participation includes:

- Vehicle Pre-Qualification (optional – prior to arriving on-site)
- Practice runs
- Qualification runs

Optional Vehicle Pre-Qualification

Prior to the on-site competition, teams may attempt to pre-qualify their vehicle. The vehicle used to pre-qualify must also be the vehicle that is entered into the competition. A team that successfully completes the pre-qualification is not required to qualify on-site during the practice days of the competition. A team that chooses not to attempt pre-qualification or does not successfully pre-qualify, is required to complete a qualification run (see **Qualification Runs** below).

To pre-qualify, all teams must build and utilize the pre-qualification course. This course consists of two pieces: a horizontal **Gate** and a vertical **Marker**. The **Gate** is 6.6 ft (2m) in length and is positioned 3.3ft (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 (ex. using PVC elbows to create two vertical legs, with a 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 must be positioned 33ft (10m) beyond the **Gate** and must touch the floor and break the surface of the water.

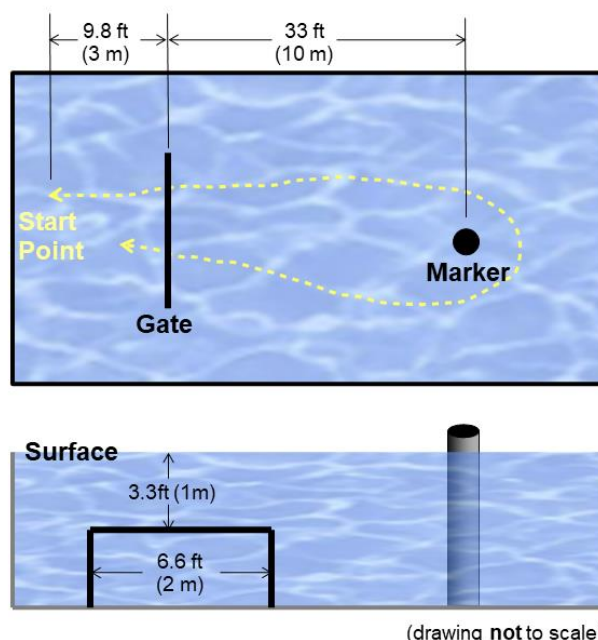


Figure 9: Pre-Qualification Runs

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 entire run must be recorded from start to finish with no breaks in the video. This is submitted to RoboSub staff for evaluation. Once evaluated, the team is notified of the results. If a team's attempt is denied and the deadline for submissions has not passed, they may submit another attempt.

Practice Runs

Practice time slots are scheduled on an ad-hoc basis by the TD team during the practice days. Teams are provided as much practice time as the venue setup allows. Each vehicle must be approved by the TD team before it is allowed into the venue.

Time Slot Breakdown

The first 5 minutes are for preparation (*preparation time*). During this period, the vehicle may not be deployed in the water. When the 5-minute limit has expired for the *preparation time* (or the team has waived the balance of the preparation time), officials begin the *performance time* clock once the vehicle is in the starting position alongside the dock. 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 run.

Qualification Runs

Teams are 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 allows the team to have 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 are 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 may attempt to pre-qualify by submitting a pre-competition video demonstrating prescribed maneuvering competency.

Vehicle Recovery / End of Run: The team lead can call for the end of a run. As long as the vehicle has passed through the gate, the time required for retrieving the vehicle back to the dock does 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 continues to run if the vehicle is retrieved before passing through the gate.

Semi-Finals Round

Each qualifying team is 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 launch site on the dock.

Vehicle Recovery / End of Run: The run continues until the *performance time* limit has expired, the team lead requests the end of the run, the judges' order the termination of the run, or the vehicle breaches the surface. The judges may order termination of the run at their discretion. Once the judges' order the end of the run, no further points may be scored. The judges' decisions on the termination of the run are final.

Finals Round

After the semi-finals round, the judges rank-order the teams based on the semi-finals round scores and select the top teams to compete in the finals round. The point totals and ranking from the teams not selected for the finals are frozen. For the finals round, all point totals are set to zero.

SECTION 3: Scoring & Awards

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3.1 Scoring

Details of task scoring, including partial scoring for select sub-elements of each task, are in development. These will be provided at a later date. Scores are calculated by the judges; all decisions of the judges are final.

Additional scoring considerations:

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.
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.
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.
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.
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.
6. Semi-Finals Round: 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. Finals Round: The "Best of" run for each vehicle is used to determine the final score.

After the competition, the judges issue overall standings. Any team accepted into the Finals Round will be ranked ahead of all teams that did not participate in the Finals Round.

3.2 Awards

Awards are provided in three categories: Design Documentation, Autonomy Challenge Final Standings and Judges' Special Awards.

3.2.1 Final Standings

Teams are awarded prize money reflective of their overall ranking after scores are calculated. The first-place teams receive a RoboNation champion banner.

3.2.2 Judges' Special Awards

Throughout the competition, judges and staff are always on the lookout for exemplary behavior from teams to acknowledge with special awards.

SECTION 4: Rules & Requirements

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4.1 Rules

1. **Vehicle Requirements:** Teams that arrive at the competition failing to meet the vehicle requirements will not be permitted on the course, until the vehicle is modified to meet all requirements. ([Section 4.3: Vehicle Requirements](#))
2. **Team Composition:** Teams must be comprised of 75% or more full-time students. ([Section 1.3: Eligibility](#))
3. **Prizes:** Only the student component of each team is eligible for cash awards.
4. **Team Lead:** One student member of the team must be designated as the “team lead”. The team lead must be conversationally fluent in English. The team lead, and only the team lead, will speak for the team during competition runs.
5. **Course Entry:** No team member is allowed to enter the course at any time (this includes wading, swimming and diving as well as floats, boats, etc.) Competition officials are responsible for recovering lost vehicles. Officials 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 not responsibility for such damage or loss.
6. **Retrieving Vehicle:** At any time, the team lead may 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 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 vehicle, the countdown lock continues while the official returns the vehicle to the start).
7. **Competition Suspended:** The officials may suspend the competition at any time they deem that it is required (i.e. for safety or security reasons).
8. **Attendance:** In-Person teams must remain on-site at the competition venue during the competition hours to be eligible for prizes. If your team does not make it into the finals, it is expected that your team displays your vehicle and be present in the Team Village during this time. (ALL teams, ALL days, ALL open hours!)
9. **AUV Safety:** Prior to entering the Autonomy Challenge courses, teams must demonstrate the ability to operate their AUV safely.
10. **Interference:** If a vehicle experiences significant interference from a piece of equipment, line, cable or official 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) then the option is lost. Interfering with the competition tasks does not qualify for this option, and a vehicle interfering with tasks may be disqualified at the judges’ discretion.
11. **Lock Score:** 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 teams.

12. **Mission End:** The run ends when any of the following occurs:

- The performance period time limit ends;
- The judges' order the end of the run;
- The team lead requests the end of the run; or
- The vehicle breaches the surface outside the octagon.

13. **Judges Decisions:** All decisions of the judges are final.

4.2 Safety

Safe operations are a priority for the RoboSub staff. All considerations to maintain safety for operators and the surrounding environment must be made. These guidelines are the minimum requirements for all teams and their systems during the competition.

1. All Radio Frequency (RF) equipment must be operated within the rules and regulations of the host country. This includes, but is not limited to, frequency, transmitting power, antenna height, etc.
2. AUV power systems must follow the safety rules and regulations of the host country as well as the team's home country.
3. RoboSub staff may suspend team operations at any time for safety or security considerations. The staff is not required to advise the team prior to the decision to terminate the run attempt. In all matters of safety, the decisions of the RoboSub staff are final.

4.2.1 Safety Inspections

Before operating in the water, all systems must pass a safety inspection. This includes, but is not limited to:

1. A Safety Inspector completes a safety checklist, verifying successful operation of all safety features at each unmanned system launch.
2. Teams demonstrate compliance with all the requirements, to include identifying all actuators, and moving parts and their associated protection mechanisms (shrouds, etc.).
3. Verification of both kill switches' operation (remote and physical). This is repeated each time a team enters the water.

4.2.2 Battery Safety Requirements

Teams are required to understand and follow battery safety best practices on the battery chemistry selected by the team. Lithium-ion chemistry batteries may become damaged and create a hazard if misused/abused, representing the greatest risk to people, facilities, and the environment. The following safety rules and requirements must be followed:

1. Teams must submit battery specifications, Material Safety Data Sheets (MSDS), and proper disposal procedures, sourced from the battery manufacturer for all batteries.
2. Teams must keep a hard copy of the battery safety documentation for all batteries in Team Village (on-site) at all times, for reference.
3. Teams must bring a LiPo safe bag(s) adequate for the lithium batteries used. LiPo bag(s) must be available at the competition and the hotel.
4. Li-Po (Lithium Polymer) battery packs need cell level safety and balancing circuits and must be labeled HAZMAT when shipped.
5. Each team must understand and follow their own country's regulations as well as those of the host nation.
6. All batteries must be stored, used, and maintained in accordance with manufacturer guidelines.

7. Teams are required to inspect their batteries daily for signs of swelling, heat, leaking, venting, burning or any other irregularities.
 - a. Lithium batteries that become too warm during use or have become swollen or malformed must be removed from use and reported to the Technical Director.
 - b. Lithium batteries that do not hold a charge must be removed from use and reported to the Technical Director.
8. A team member must be present at all times to monitor charging batteries.
9. At the competition site, if any of the above battery conditions are observed students must immediately notify the Technical Director or RoboSub staff and provide the battery specifications and safety information.
10. At the hotel, if a battery irregularity occurs at any time, students must notify RoboNation's Senior Events Manager, Cheri Koch immediately by phone at 850.642.0536 and provide the battery specifications and safety information.
11. Failed or failing Lithium-ion batteries must be handled in accordance with manufacturer's safety and disposal guidelines. In the absence of specific guidelines, batteries must be placed in a LiPo safe bag, which must then be placed in a bucket, covered with sand, and placed in a designated safety zone.
12. Teams are only permitted to change or replace AUV batteries in Team Village.

4.3 Vehicle Requirements

The following is a list of minimal requirements for a vehicle to be permitted access to a course. **Teams that arrive at the competition failing to meet the vehicle requirements will not be permitted on the course until the vehicle is modified to meet all requirements.**

4.3.1 AUV Requirements

- **Inspection:** Each team may enter one or multiple vehicles into the competition. Each vehicle is physically inspected by the TD team. The TD team may disqualify any vehicle that they deem to pose an unreasonable safety hazard to participants, staff, or 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.
- **Autonomy:** Vehicles shall be fully autonomous and shall have all autonomy decisions made onboard the AUV. During a run, no communication is permitted between the vehicle and any person or off-board computer. Each vehicle must operate solely on its ability to sense and maneuver in the arena using on-board resources.
- **Submerge:** During qualifying, semi-finals or finals run, each vehicle must operate autonomously during its run. While carrying out the run, no communication is permitted between the vehicle and any person or off-board computer. When performing a qualifying, semi-finals or finals 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.
- **Weight and Size:** The weight of each individual vehicle must be less than the maximum allowed. Note that bonus points are awarded to vehicles below a certain weight, and penalties assessed for those that exceed it. The entire vehicle must fit within the volume described in the corresponding section. ([Section 2.4.1 Weight and Thrust Measurements](#))

- **Batteries:** 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 on the [forum](#). ([Section 4.2.2 Battery Safety Requirements](#))
- **Markers:** No materials (except for the markers/torpedoes and compressed air) may be released by the vehicle into the waters of the arena. ([Section 4.5.1 Markers](#))
- **Torpedoes:** 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, tests may be conducted either in the water or in an open area pointing away from everyone and everything. ([Section 4.5.2 Torpedoes](#))
- **Harness:** Vehicles are required to be slung on a harness or sling of some type. Even if the vehicle is light enough to hand carry, this requirement is in place to avoid harm to the vehicle. The harness/sling is used to weigh the vehicle and launch/recover.
- **Kill Switch:** 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). Vehicles will not be allowed in the water without a properly working kill switch.
- **Shrouded:** 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. If shrouded, commercial thrusters can be used as is. Vehicles will not be allowed in the water without prop shrouds.
- **Buoyancy:** 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.
- **Suspension:** 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 officials will be held in confidence until the end of the competition.

4.3.2 Multiple Vehicle Requirements

Up to two vehicles per team are allowed in the competition. Along with the [AUV Requirements](#), teams who enter multiple vehicles must follow these specifications:

- **Volume:** The total dry volume for all the vehicles must fit within the maximum volume defined in the requirements. The vehicles are not required to start joined together, nor are they required to rejoin at the completion of the run.
- **Weight and Size:** Each vehicle is weighed, and the bonuses/penalties are calculated on a per vehicle basis ([Section 2.4 Mandatory Activities](#)).
- **Gate:** From the dock, each vehicle must pass through the validation gate first before heading off for its desired task.
- **Run Time:** 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 are returned to the dock and can be redeployed at any time.
- **Time Stop:** 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).

- **Inter-Vehicle Communication:** Teams wishing to have communication between each vehicle must post their method and frequencies on the [forum](#). Acoustic frequencies that are the frequency range used by the pingers, are always off limits for inter-sub communication. 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.

4.4 Competition Specifications

4.4.1 Markers

- Each marker must fit within a box 2.0" square and 6" long (5.1 x 5.1 x 15.2 cm).
- Each marker must weigh no more than 2.0 lbs (0.91 kg) in air. Any marker that exceeds these limits by less than 10% results in a 500-point penalty. Any marker that exceeds these limits by more than 10% are disqualified.
- Each marker must bear the team's name, color or emblem.
- Markers are cleared from the arena after each run.
- A vehicle may carry up to two markers.
- It is recommended to bring backup markers in the case of lost markers.

4.4.2 Torpedoes

The torpedo size, weight, and marking requirements are the same as the Markers.

- Each torpedo must fit within a box 2.0" square and 6" long (5.1 x 5.1 x 15.2 cm).
- Each torpedo must weigh no more than 2.0 lbs (0.91 kg) in air. Any torpedo that exceeds these limits by less than 10% results in a 500-point penalty. Any marker that exceeds these limits by more than 10% are disqualified.
- Each torpedo must bear the team's name, color or emblem.
- 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.
- Torpedoes are cleared from the arena after each run.
- A vehicle may carry up to two torpedoes.
- It is recommended to bring backup torpedoes in the case of lost torpedoes.

4.4.3 Pingers

The pingers are Benthos ALP-365. The Benthos ALP-365 is user selectable from 25 to 40 kHz in 0.5 kHz increments. They are only set to an integer frequency (25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 or 40) and are set to the maximum power. The pingers in each section use the same frequency.

For example, the two pingers in section A both have the same frequency, and the two pingers in section B both have the same frequency (but different from section A). There are four different frequencies used, one for each section, and only one pinger in each section are active at a time. The ping for each section is deconflicted with the pings in other sections such that only one pinger pings at a time. As shown in Figure 11, the frequencies for the sections are:

- A – 30kHz
- B – 40kHz
- C – 25kHz
- D – 35kHz

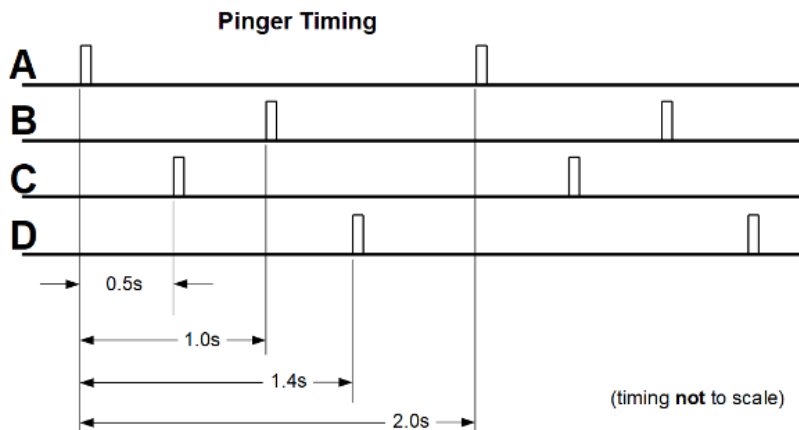


Figure 10: Pinger timer for the four sections

SECTION 5: How to Compete

RoboSub 2022

www.robosub.org

5.1 Register and Intent to Compete

5.1.1 Intent to Compete

Before the RoboSub 2022 Registration opens, teams are invited to complete an Intent to Compete form expressing intent to compete in the 2022 RoboSub Competition. The Intent to Compete form is available on the RoboSub website, RoboSub.org/2022.

5.1.2 Register to Compete

All teams are required to register to compete using the Registration form found on the RoboSub website, RoboSub.org/2022. This registration collects each team's point of contact information, demographics, and the Pre-Competition Requirements outlined in [Section 5.2](#).

Registration Fees

To complete the RoboSub 2022 registration, teams must pay the registration fee. Teams who register early are eligible for the early-bird fee.

- Early-Bird Fee: \$800 USD (*Register before February 13, 2022.*)
- Registration Fee: \$900 USD

5.1.3 Data Sharing Access Requirements

During the registration process, teams must provide a generic email account and a team acronym that is used in the Data Sharing project ([Section 5.6](#)). The generic email can be associated with any email provider. An example of the Generic Email is: robotx-team@outlook.com. The team acronym must be within 2-10 characters, abbreviating the team's school or organization. Examples of the team acronym are: RN or ROBOTTEAM.

Access is given to teams that complete the Intent to Compete form and/or Registration form. Only official registered teams maintain access to the Data Sharing project for the RoboSub 2022 season.

5.2 Pre-Competition Requirements

These requirements are collected prior to participation on-site at the competition, during the registration process.

5.2.1 Team Information Package

Teams are required to submit a team roster including all participants that support the RoboSub 2022 effort, liability waivers, forms, and other contact information.

5.2.2 On-Site Requirements (In-Person Teams)

All In-Person teams are required to submit battery specifications, a COVID-19 plan, and a shipping plan.

Battery Safety Requirements

Teams are required to submit battery specifications, Material Safety Data Sheets (MSDS), and proper disposal procedures, sourced from the battery manufacturer for all batteries. More information can be found in [Section 4.2 Safety](#).

COVID-19 Team Plan

Teams are required to submit a COVID-19 Plan prior to arrival. This plan must include:

1. Plan for isolating team members showing COVID-19 symptoms, including plans to obtain/pay for an additional hotel room / isolation area.
2. Plan for testing of team members showing COVID-19 symptoms or those having contact with COVID-19 positive team member.
3. Plan for quarantining team members testing positive for COVID-19, including contingency plans for extended stay until a negative test is received.
4. Emergency plan in case student is hospitalized for COVID-19. Must include:
 - Emergency contact info for all team members.
 - Health insurance / travel insurance information for each team member.
 - Plan for travel home once team member is released from medical care.

Shipping Plan

Teams are required to submit a shipping plan to facilitate shipment receipt/handling at the competition hotel. Shipping guidelines can be found in [Section 5.4.3 Shipping](#). This shipping plan must include:

1. Box/Crate count (How many total boxes/crates are in the shipment?)
2. Weight of each box/crate
3. Dimensions of each box/crate
4. Name of shipping company used
5. Pick-up Address
6. Return Address
7. Name and contact information for Team Shipping Point of Contact
8. Battery specific provisions for shipments that include batteries.

(Note: Shipping guidelines for lithium batteries differ by country and by shipping company. Check with your shipping company to determine requirements for shipping new batteries vs. used batteries AND make sure that you are familiar with your shipper's facilities, operating hours, and requirements shipping your vehicle / batteries back home after the competition.)

5.2.4 Design Documentation Package

Teams are required to submit the team website, technical design report, and skills video of their Design Documentation prior to being on-site at the competition. Guidelines can be found in [Section 2.3 Design Documentation](#).

5.2.5 Video Demonstration (Online Teams)

Online teams showcase their vehicle performance through a video demonstration of autonomous completion of a range of behaviors. Instructions can be found in [Section 2.4.1 Video Demonstration](#).

5.2.6 Optional Pre-Qualification Maneuver (In-Person Teams)

In-Person teams may attempt to pre-qualify their vehicle for the Autonomy Challenge with a video performing the qualification maneuver. Approved pre-qualification attempts advance to Semi-Finals. Instructions can be found in [Section 2.6](#).

5.2.7 Optional Community & Outreach

Teams are invited to outline their educational outreach efforts. This activity is not scored; however, it is shared online for the community and can be eligible for special awards and recognition. Teams may submit a description of their activities and any supporting documents, photos, or videos.

5.3 Timeline

| Date/Deadline | Event |
|-----------------------------|---|
| June – January 2022 | Intent to Compete |
| January 26 – March 31, 2022 | Registration |
| June 5, 2022 | Pre-Competition Deadlines: <ul style="list-style-type: none">• Team Information• On-Site Requirements (In-Person Teams) |
| June 12, 2022 | Pre-Competition Deadlines: <ul style="list-style-type: none">• Design Documentation• Video Demonstration (Online Teams)• Optional Pre-Qualification (In-Person Teams)• Optional Community & Outreach Full Refund Cancellation Deadline |
| July 25-31, 2022 | RoboSub 2022 |

5.4 Logistics & Travel

5.4.1 Shipping

Additional shipping guidelines will be released in future issues of this Team Handbook.

Equipment Arrival

Teams should arrange shipments should arrive no earlier than 3 days prior to event.

Equipment Outbound Pick-Up

Teams should arrange shipments to ensure their package(s) is picked up / dropped off BEFORE the team departs to return home. RoboNation and the hotel staff are not responsible for ensuring that team's outbound shipment gets picked up.

5.4.2 Health and Safety

COVID-19 Protocols and Local Guidance

The Health and Safety of the RoboNation community is our number one priority. RoboNation follows all local and state health guidelines. We will continue to communicate with any changes to on-site protocols as we approach RoboSub 2022. Please follow safety guidelines at work, at home, and in the community to help slow the spread of coronavirus.

Updated rules and restrictions for travel to and within California are available at the following websites:

- California's COVID-19 website, covid19.ca.gov
- Domestic Travel in the United States, cdc.gov
- International Travel to the United States, cdc.gov

5.4.3 Travel + Lodging

Teams are responsible for coordinating their own lodging and travel plans.

Lodging—Hotels

Information on the selected event hotel and reservations will be released in future issues of this Team Handbook.

International Travel

Invitation Letter – During the registration process, international teams are given the opportunity to request an invitation letter issued by RoboNation.

VISA Process – It is recommended for international teams to acquire a B-1 Visitor VISA to attend the competition. However, if the team has plans for any other activities besides the competition, they may choose to investigate other types of visas. Explore the different types of visas: travel.state.gov.

5.4.4 On-site Logistics

Team Village

Each team is provided with a covered working area with access to electrical power and Internet access. This is where teams should conduct development, maintenance, and repair of their systems. Batteries may be charged during the day at the Team Village but may not be left charging overnight.

Team Course Operating Areas

Teams are provided with an area along the pool near the course areas where they are able to set up their equipment. This space consists of a tent-covered area with tables, power, and a hard-wired Ethernet connection.

Power

The United States uses a 120V 60Hz 15A electrical outlet plug. Usually three 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 11: US electrical outlets

5.5 Communications

5.5.1 Pre-Competition Communications

RoboSub teams have a variety of opportunities to interact with each other and the RoboSub staff.

Team Time Meetings

Leading up to the on-site competition, there are regularly held virtual meetings where teams are asked to have a team representative join. These Team Time meetings are hosted by the RoboSub organizers and technical team to provide teams with competition updates and the opportunity to ask questions.

RoboSub Discussion Forum

All questions, comments, and suggestions should be posted on the [RoboSub Discussion Forum](#). Teams are encouraged to actively participate in the online community and monitor it for the latest news and updates regarding all things RoboSub.

Band App

The RoboSub Community in the Band App is used to keep registered RoboSub teams updated on the latest announcements, resources, and special deals throughout the competition season. Each team member is encouraged to download the Band App (band.us), available on Android and iOS, and get to know the other RoboSub teams. Access information is provided in the team registration process, outlined in [Section 5.1 Register and Intent to Compete](#).

5.5.2 On-site Communications

Team Lead

Each team must designate a student team member as their team lead. The team lead is the only person allowed to speak for the team. The team lead is the only person permitted to request vehicle deployment, run start, run end, or vehicle retrieval. The team lead must be conversationally fluent in English to communicate with RoboSub staff. Teams who do not have members fluent in English should contact RoboSub staff as soon as possible.

Technical Director Team

The RoboSub Technical Director Team consists of:

- Technical Director
- Course Managers

Other RoboSub Staff

The RoboSub Staff are identified with “Staff” on the back of their RoboSub shirts.

5.5.3 RoboSub Website

The official competition website is www.RoboSub.org/2022. This website includes all official documents and a detailed list of the registered RoboSub teams. Helpful resources, past competition results, and other engagement opportunities can be found on this website. Information and documents are updated regularly, and it is the team’s responsibility to check the website for updates.

5.6 Data Sharing

A Data Sharing project has been established for registered teams competing in RoboNation’s RoboSub, RoboSub, and RobotX competitions. This project aims to increase collaboration between teams and to provide access to shared resources and test data to validate and debug the reliability and robustness of teams’ machine vision algorithms. Access information is provided in the team registration process, outlined in [Section 5.1 Register and Intent to Compete](#).

For more information on Data Sharing, visit the RoboNation Data Sharing website: RoboSub.org/data-sharing.

SECTION 6: Glossary & Acronyms

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6.1 Glossary

| Phrase | Definition |
|---|---|
| Semi-Finals & Finals Courses | These courses are designed to allow demonstration of autonomous execution of multiple tasks. They contain an instance of each task. |
| Team Lead | Designated spokesperson for each team. |
| Technical Director Team | Technical team that runs the courses, safety inspections, set-up, and tear-down. |
| RoboSub Staff | RoboSub support personnel. |
| Judge | Subject Matter Experts that observe and score the Autonomy Challenge and Design Documentation. |
| Sponsor | Organizations that provide support to RoboSub. |

6.2 Acronyms

| Acronym | Definition |
|------------|-------------------------------|
| AUV | Autonomous Underwater Vehicle |
| N/A | Not available |
| TBD | To be determined |
| TD | Technical Director |
| TDR | Technical Design Report |

Appendix A: Technical Design Report (TDR)

*RoboSub 2022**www.robosub.org*

A.1. Paper Preparation Overview

Each team is required to submit a TDR that describes the design of their vehicle, as well as strategies for their approach to the tasks. The TDR should also include rationale for design choices. Teams must follow the TDR instructions provided below.

A.2. Format

The format of the written paper shall adhere to the following guidelines:

- **5 page limit (excluding References and Appendices)**
- 8.5 x 11 in. page size
- Margins ≥ 0.8 in.
- Font: Times New Roman 12pt
- Header on every page including team name and page number
- Submitted in .pdf format

Access all past competitor's papers on the Past Teams' page, RoboSub.org/past-programs. (Click on the year you'd like to view and scroll down to the team section.)

A.3. Paper Contents

The written paper consists of six mandatory Sections and one mandatory Appendix. Additional sections may be included; however, the overall limit of 10 pages applies (excluding References and Appendices). In general, the editorial style for IEEE Conference Proceedings should be followed:

www.ieee.org/conferences/publishing/templates.html. The two-column format is optional. We recommend that papers be peer-reviewed prior to submission. You can utilize resources at your institution, teams entering other RoboNation competitions, or on the community forum for this peer-review. Professional editing services are also available: secure.aje.com/en/default/submitb/select.

A.3.1 Abstract

The abstract is a short summary of the main points in the paper. The paper should primarily describe the linkage between your overall competition strategy and your system architecture, design and engineering decisions.

A.3.2 Competition Strategy

This section should discuss how the team plans on approaching the course and how the vehicle design relates to this approach. The course consists of multiple tasks with associated points for accomplishment. The only required task is passing through the start gate. Other tasks are optional and can be attempted in any order. The more tasks a vehicle is designed and engineered to accomplish, the more complex the overall vehicle system will be. The discussion should include the team's consideration of the trade-offs between system complexity and reliability. For example, teams have a limited number of working hours to prepare for the competition; this time could be spent adding additional capabilities or testing and improving the reliability of an existing capability. As system complexity grows, changes in subsystems can propagate in unmanageable ways when time is limited. Clearly, the goal of a competition is to score more points than the other teams. There are many ways to do this. Studying past

competitions may be instructive. Based on history and the system engineering talents of your current team, describe your strategic vision.

A.3.2 Design Creativity

Given your strategy for winning and your approach to managing complexity, describe the creative aspects of your system. Novelty may occur at component, subsystem, and/or integrated system levels. Describe your experience in making both architectural/design decisions and system engineering decisions. This section should not include detailed component descriptions and/or specifications not of original design. The latter should be described in TDR Appendix A.

A.3.2 Experimental Results

This section should describe various tests planned and/or accomplished to date, both in-water and in simulation. There is a strong correlation between in-water testing time and competitive performance in the arena. Given unique challenges leading up to this year's competition like the global Covid-19 pandemic in addition to typical student time constraints, balancing creative design and system engineering with testing and experimentation can be a challenge. How did your team estimate the amount of testing required to meet your reliability goals? How did/sill you balance the demands of design and engineering with those of testing and experimentation?

A.3.2 Acknowledgements

Participating in the competition, as in all research projects, involves marshalling resources and support beyond the efforts of individual team members. This support can take many forms, such as technical advice, labor, equipment, facilities, and monetary contributions. Acknowledging those who have underwritten your efforts is important.

A.3.2 References

As with any technical publication, original ideas and content not generated by the paper's authors should be properly cited. While there are many citation styles, the IEEE Conference Proceedings style should be used, found on the following link:

www.ieee.org/conferences/publishing/templates.html.

A.3.2 Appendix A: Component Specifications

In the past, detailed descriptions of components constituted the bulk of many written paper submissions. Such detail often distracts from understanding the team's underlying strategic thinking, design and engineering decisions, or novel contributions. Teams should list and indicate the "status" of components selected/purchased/installed for the vehicle in the table below. Where components were developed by the team versus purchased off the shelf, this information should be included. Also, if commercial off the shelf equipment was significantly modified this should be noted. This standardized table will help document and track trends in component (hardware and software) usage and team metrics. Under the column marked "Specs" you may provide a web link to the manufacturer's specifications. The form below is generic and you should report all components you have included in your vehicle design.

| Component | Vendor | Model/Type | Specs | Custom/Purchased | Cost | Year of Purchase |
|---------------------------------|--------|------------|-------|------------------|------|------------------|
| Buoyancy Control | | | | | | |
| Frame | | | | | | |
| Waterproof Housing | | | | | | |
| Waterproof Connectors | | | | | | |
| Thrusters | | | | | | |
| Motor Control | | | | | | |
| High Level Control | | | | | | |
| Actuators | | | | | | |
| Propellers | | | | | | |
| Battery | | | | | | |
| Converter | | | | | | |
| Regulator | | | | | | |
| CPU | | | | | | |
| Internal Comm Network | | | | | | |
| External Comm Interface | | | | | | |
| Compass | | | | | | |
| Inertial Measurement Unit (IMU) | | | | | | |
| Doppler Velocity Log (DVL) | | | | | | |
| Manipulator | | | | | | |
| Algorithms | | | | | | |
| Vision | | | | | | |
| Acoustics | | | | | | |
| Localization and Mapping | | | | | | |
| Autonomy | | | | | | |
| Open-Source Software | | | | | | |