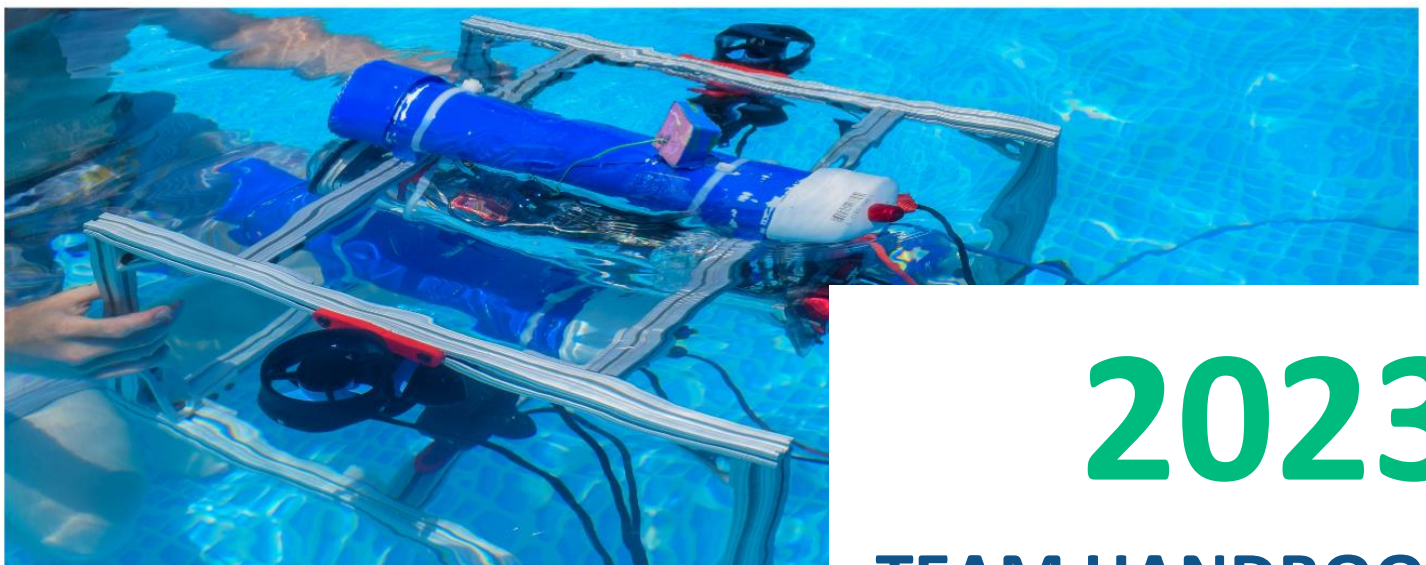robosub
*Whirlpool* X-treme

# 2023

## TEAM HANDBOOK

Version 1 (April 2023)

# Introduction

**Welcome to the RoboSub Competition!**
This Team Handbook contains information needed 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 2023 RoboSub Competition is hosted by RoboNation, in collaboration with Naval Underwater Warfare Center (NIWC) Pacific and the U.S. Office of Naval Research (ONR).

# Table of Contents

| Version | Changes | Date |
|---------|---------|------|
| V1 | First release of RoboSub 2023 Team Handbook. | 21 April 2023 |

Table 1. Document Version Log

# SECTION 1: RoboSub Overview

*RoboSub 2023*                                                                          *www.robosub.org*

## 1.1    Dates & Venue
The 2023 RoboSub Competition (RoboSub 2023) will be held 31 July – 06 August 2023 at the NIWC Pacific TRANSDEC Facility in San Diego, California, USA.

## 1.2    Mission and Theme
The TV series Stargate SG-1 first aired in 1997 (26 years ago) and was based off the film Stargate (1994). Colonel Jack O'Neill and his SG-1 team, Danial Jackson, Samantha Carter and Teal'c, set out to explore the mysteries of the Stargate.  SG-1 is an elite United States Air Force special operations team, one of about 20 teams from Earth, who explore the galaxy and defend Earth against alien threats such as the Goa'uld, the Replicators and the Ori.

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:

- *Oh for crying out loud* (Coin Flip)
- *Location* (Bins)
- *Goa'uld Attack* (Torpedoes)
- *Destination* (Gate)
- *Start Dialing* (Buoys)
- *Engaging Chevrons / DHD* (Octagon)

## Competition Structure
RoboSub 2023 includes the (1) Autonomy Challenge that demonstrates autonomous performance and safety; and (2) Design Documentation that presents each team's work and vehicle design.

## 1.4    Eligibility
Student teams from anywhere in the world are eligible to participate. All teams must build an AUV to compete and may enter one or two vehicles in the competition. *

*First-year teams* are eligible to participate in RoboSub without an AUV. These teams are expected to participate in Design Documentation and send representatives on-site at the event as a learning experience. First-year teams are expected to indicate this option in their registration form. The link to the registration form can be found on the _RoboSub 2023 website_.

### 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: | Registration Questions: | Technical Questions: | On-Site Logistics/Safety: |
|---|---|---|---|
| autonomy@robonation.org | support@robonation.org | robosub.org/forum | events@robonation.org |
| | | | 850.642.0536 |

# SECTION 2:  Competition

*RoboSub 2023*                                                    *www.robosub.org*

This section includes general competition details 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:** Qualified teams complete runs to qualify for the Finals Round.
  - **Finals Round:** Qualified teams complete runs on the Finals Course.

See Appendix A: Competition Schedule for the detailed competition schedule.

| Date | Event | Location |
|---|---|---|
| **16 June** | Design Documentation (prior to on-site competition) | Online |
| **31 July (afternoon)** | Team Check-in / Orientation<br>*All teams are required to attend with at least one representative.* | The Dana on Mission Bay |
| **1-3 August** | Vehicle Assembly + Safety Inspections<br>Practice & Qualification Attempts | TRANSDEC Facility |
| **4-5 August** | Semi-Finals Round & Wild Card<br>Design Presentations | |
| **6 August** | Third Chance / Finalist Practice Runs<br>Finals Round<br>Awards | |

Table 2. Preliminary RoboSub Schedule (subject to change)

## 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 must include:

- Current team name and contact information
- Name, picture and contact information for each contributing member
- Vehicle photos and/or videos
- Supporting media, which may include:
    - 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:

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

The website submission is worth a total of 200 points. Below are the scoring metrics the judges are provided to evaluate teams' websites.

*Team Information Scoring Metrics (Maximum Points: 50)*

| | |
|---|---|
| **31-50 points** | Team website includes all required team information, including the team's name and contact information, and a list of team members and sponsors. All mentions of the vehicle are relevant to the current competition year. |
| **16-30 points** | Team website provides a brief introduction on the team, team members and sponsors. There is limited supporting media on the vehicle. |
| **1-15 points** | Team website introduces the team. There is no mention of the vehicle. |
| **0 points** | The required team information is not included on the website. |

*Vehicle Design Documentation Scoring Metrics (Maximum Points: 75)*

| | |
|---|---|
| **51-75 points** | Vehicle development and testing process is thoroughly documented with instructional and informative supporting media and historical recording. This could include: photographs, diagrams, videos, procedures (text + images), design documentation (text + images + video), or blogs for historical records. |
| **26-50 points** | Vehicle development and testing process is briefly documented. Limited supporting media is accessible. |
| **1-25 points** | Few pictures or videos of the vehicle, but no instructional or informative documentation included. |
| **0 points** | No visuals or documentation of the vehicle is available on the website. |

*Website Quality Scoring Metrics (Maximum Points: 75)*

| | |
|---|---|
| **51-75 points** | Website places a heavy emphasis on human factors. Layout is visually appealing, easily maneuverable, and does an excellent job of drawing user's attention to relevant content. |
| **26-50 points** | Website considers some user experience. Layout does an acceptable job of drawing user's attention. Users can navigate the site to find most information. |
| **1-25 points** | Layout and/or design makes it difficult to find information. Website does not have a user friendly display. |
| **0 points** | Website is busy and difficult to read; no guidance on maneuvering site. |

**Technical Design Report (TDR)**

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 and scoring metrics for this report are available in Appendix B: Technical Design Report.

**Team Introduction Video**

Teams are required to create a video introducing their team members and highlighting their team personality. This video is meant to be a creative showcase of what makes each team unique, such as, the mission of the team or the team culture.

Format Requirements:
1. Video must be conducted in English or include subtitles in English.
2. Video must be no more than three (3) minutes in length.
3. Video may include graphics, vehicle performance, and/or simulation.
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.

The team introduction video submission is worth a total of 120 points. Below are the scoring metrics the judges are provided to evaluate teams' videos.

*Formatting Scoring Metrics (Maximum Points: 10)*

| | |
|---|---|
| **10 points** | All formatting guidelines are followed. Video is conducted in English or includes English subtitles, video is no more than 3 minutes in length, and video is hosted on the team's website or YouTube channel. |
| **0 points** | Video does not follow formatting requirements. |

*Video Quality Scoring Metrics (Maximum Points: 25)*

| | |
|---|---|
| **21-25 points** | Visuals immediately draws attention. Overall, the video is solid in frame (not shaky), correctly lighted, in precision focus, appropriately segmented, and visually clear in all respects. Transitions between segments are clear and smooth. The video is less than 3 minutes total runtime. |
| **11-20 points** | Good visual impression. Majority of video is clear, adequately lit, and places people and objects in recognizable scale and perspective. Video segments are generally of the appropriate length, transition well, and are related to each other. Use of video effects is good. Runtime is less than 3 minutes. |
| **1-10 points** | Frames and segments are shaky, distracting or poorly lit. Some segments are out of focus. Some heavy shadows are obscuring viewpoint. Visual effects are distracting rather than informative. Video exceeds 3 minutes in length. |
| **0 points** | No focus on visual quality. Video exceeds 3 minutes in length. |

*Information Organization Scoring Metrics (Maximum Points: 25)*

| | |
|---|---|
| **21-25 points** | Video is a complete introduction of the team makeup including team members, sub-teams, activities, mentors, and major sponsors. Organization of video information is logical and compelling. |
| **11-20 points** | Video information is scattered throughout video, leaving the viewer lacking complete understanding of project. |
| **1-10 points** | Video provides incomplete information regarding the team members, activities, or progress. The information presented is extraneous, confusing, or low quality. |
| **0 points** | No organizational strategy is apparent. |

*Clear and Effective Communication Scoring Metrics (Maximum Points: 30)*

| | |
|---|---|
| **21-30 points** | Effective and compelling use of video medium to communicate the introduction of the team. Easy for non-technical viewer to understand and support. [You're left wanting to learn more.] |
| **11-20 points** | Exhibits moderately compelling use of video medium to communicate the introduction of the team. Strong potential, moderately compelling, mostly understandable to non-technical viewer. [You're left strongly considering to learn more.] |

| 1-10 points | Exhibits some ability to use video to attempt to introduce team and project overview. Difficult for viewer to understand and/or was not compelling. [You're left unenthused.] |
| 0 points | Poorly used video medium to convey team introduction. Information was as not clearly understood and was not compelling. [You're left with little information.] |

*Creativity Scoring Metrics (Maximum Points: 30)*

| 21-30 points | Team creativity and enthusiasm is clearly evident in the video. Appropriate use of humor is understated and well done. Video captures user's attention without diminishing or obscuring the information delivered. Effects of careful post-production editing are clear. |
| 11-20 points | Some creativity has been used throughout video. The visual style and tone are consistent throughout video. |
| 1-10 points | Little attempts made to include creative or imaginative ideas in video. Poor visual effects and enthusiasm for the project. |
| 0 points | Little imagination or creativity is evident in production. Information is presented lacking enthusiasm. |

### 2.2.2 Delivered During On-Site Competition

**Design Presentation**

Teams give a design presentation to a panel of subject matter expert judges. Each team must present what they plan to do on the course, and how that plan impacted their design and selections. This oral presentation must be conducted in English and may include visual aids. Teams must provide their own computer and adapters for an HDMI connecter to use the presentation display monitor. Teams receive an assigned 15-minute presentation time.

This presentation includes:
- Team presentation – 10 minutes
- Judges' question and answer - 5 minutes

After the presentation, teams should make themselves available for a team photo. Once published, the latest presentation schedule can be found here: robosub.org/2023.

The design presentation submission is worth a total of 200 points. Below are the scoring metrics with guidance provided to the judges during evaluations.

*Scoring Metrics (Maximum Points: 200)*

| **Competition Strategy** 0-60 points | The team demonstrates a good understanding of rules, requirements, and autonomy challenges, and explains how the team developed their competition strategy. Team effectively describes metrics of success for the competition. |
| **Design Rationale** 0-60 points | The team's design approach clearly relates to their competition strategy. System, subsystem, and component testing as well as lessons learned are applied throughout the system development process. |

| | |
|---|---|
| **Effective Communication & Professionalism** 0-40 points | Presentation materials and team member knowledge effectively support the team's message. Team members are engaging, respectful, and professional while interacting in a positive manner with the judges and each other. |
| **Judge Questions & Dialogue** 0-40 points | The team effectively uses evidence, experience, and research from project to inform responses to all questions and discussion. |

## 2.3   Autonomy Challenge

These challenges showcase AUV performance through autonomous behaviors designed to represent research and real-world applications. In the next sections of this document, you'll find details on mandatory activities to demonstrate the ability to safely operate your AUV (2.4), task descriptions (2.5), and how to practice and qualify for semi-finals and finals rounds (2.6).

**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 will 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)

## 2.4   Mandatory Activities

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 on-board kill switch)
- Safety issues related to propellors or hazards
- All systems are properly secured

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

**Weight Measurement**
While suspended in air, vehicles are weighed before each semi-finals and finals run.
Table 3: Vehicle weight in air with Bonus or Penalties shows the bonuses and penalties associated with a vehicle's weight in air.
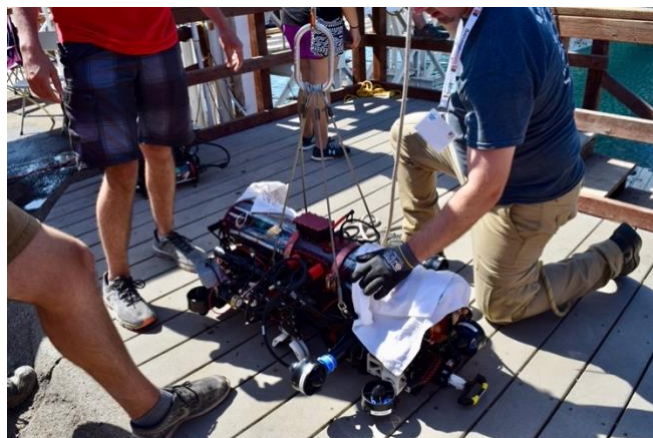


Figure 1: Example Vehicle Weight Measurement

Table 3: Vehicle weight in air with Bonus or Penalties

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

## 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.

More details for each task will be released at a later date. Review the task ideas here: robosub.org/2023.

## 2.6 Autonomy Challenge Sequence of Events

This section outlines the sequence of events for the Autonomy Challenge. The competition allows for days of practice, qualifying, semi-final, and finals runs.

### 2.6.1    OPTIONAL Pre-Qualification Attempt

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 passes the pre-qualification will automatically qualify for Semi-Finals and 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 on-site (see **Qualification Runs** below).



Figure 2: Pre-Qualification Runs

### How to Build Pre-Qualification Course

The approved pre-qualification course consists of two pieces:

    (1)  horizontal **Gate**, and
    (2)  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.
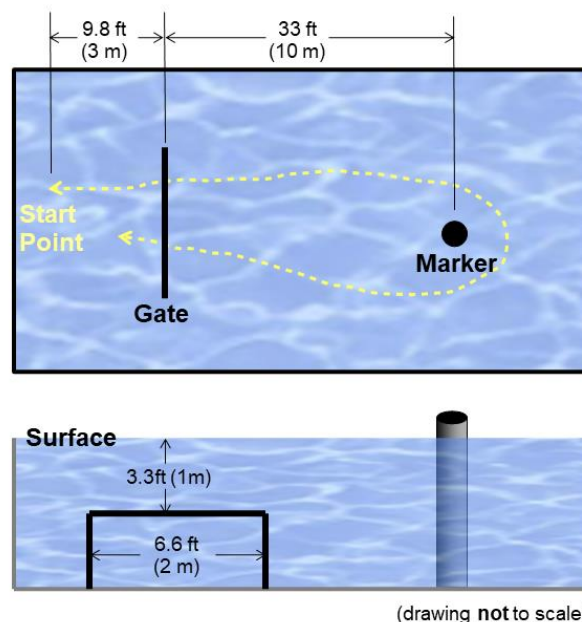
### Pre-Qualification Maneuver

In a fully autonomous run, the vehicle must

- submerge and start 9.8 ft (3m) behind the **Gate**,
- pass through the **Gate**,
- circle around the **Marker**, and
- pass back through the **Gate.**

Everything attached to the vehicle must submerge with the vehicle (nothing floating on the surface). The maneuver is successful if this is all accomplished without breaching the surface. The entire run must be recorded from start to finish with no breaks in the video.

### Submit Pre-Qualification Attempt Video

In the registration system, teams have the opportunity to upload the pre-qualification video. This video is submitted to RoboNation 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.

### 2.6.2 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 cleared by the TD team with a mandatory safety check before it can enter a practice course. Teams can sign up for one 30-minute practice timeslot at a time. Once their timeslot has completed, the team is permitted to sign up for the next available timeslot for that practice day.

### 2.6.3 Qualification Runs

To advance in the competition, teams are required to complete a qualification run. On practice days, a team may request that their run be observed as a qualification run anytime during a team's practice run. In order to successfully qualify, the vehicle must pass through the gate autonomously with everything attached to the vehicle submerging with the vehicle. 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.

**Wild Card Slots**

For any team that has not qualified during the practice days, wild card slots are available during the semi-finals days. Teams 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-qualified team.

### 2.6.4 Semi-Finals Round

There are two semi-finals days. Each qualified team is assigned one time slot on each day to perform the mission. Two of the practice courses are converted into semi-finals courses. Qualified teams are required to conduct a run in each of the two courses across the two semi-finals days. 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.

**Semi-Finals Timeslot**

A team will have 20 minutes for their semi-finals timeslot. 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. 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.

**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. As long as a vehicle has passed through the gate, the *performance time* is stopped during the retrieval of the vehicle.

### 2.6.5 Finals Round

After the semi-finals round, the judges rank-order the teams based on the semi-finals 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

## 3.1    Scoring

Scores are calculated by the judges; all decisions of the judges are final.

### 3.1.1    Design Documentation Scoring

Design documentation must be submitted in accordance with the requirements outlined in Section 2.2 and the deadlines listed in Section 5.3., to be eligible for full points. After the competition, the judges will issue overall standings in the design documentation portion of the competition. The design documentation scoring breakdown is summarized in the table below.

| Design Documentation | Potential Points |
|---|---|
| Website | 200 |
| Technical Design Report | 180 |
| Team Introduction Video | 120 |
| Design Presentation | 200 |
| **Total Potential Points** | **700** |

### 3.1.2    Autonomy Challenge Scoring

The Autonomy Challenge occurs in three rounds: Qualifying, Semi-Finals, and Finals. Points are awarded only in the Semi-Final and Final Rounds, as outlined in this section. Upon completion of the Semi-Finals Round, the judges will announce the top-scoring teams who will progress to the Finals Round. The judges have the discretion to select the number of teams advancing to the Finals Round.

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

**Point Breakdown**

Each of the tasks has a point value associated with it, to be published at a later date.  The tasks can be completed in any order by one or more vehicles.  The recovered object must be attached to the vehicle when the vehicle is on the surface to obtain maximum points for "surfacing with object".

During a scored timeslot, the team lead may end the run at any time and keep the accumulated points. The team may decide to start another run, in an attempt to accomplish more/different tasks.

*Semi-Finals Points – Last Run*
For semi-finals, at the start of a new run, the points accumulated from the previous run are forfeited. The only points which are recorded are from the very **last** run.

*Finals Points – Best Run*
For the finals, the **best** run will be used for the final points.  Therefore, a team may try to accomplish as many runs as time allows, and the run that has accumulated the most points will be used for their final score.  If the minimum requirements have been met, the remaining time after each run will be recorded and used to calculate a time bonus.  For example, after the first run, a team has met the time bonus

requirements with 10 minutes remaining on the clock.  Those 10 minutes are used to calculate the time bonus for that run, regardless of what happens with the next run.

**Pinger Tasks**
**Goa'uld Attack** and **Engaging Chevrons / DHD** will *only* be marked with a pinger.  There will be no path markers that point to either task.  A team may request that a specific pinger be switched on (pinger near **Goa'uld Attack**, or pinger near **Engaging Chevrons / DHD**).  At any time during the run, the team lead may ask to have the pinger switched to the other task.  This switch can be done as many times as the team lead asks.  Additional points are awarded if the team requests a random pinger.

*Random Pinger*
If a vehicle can score points at both pinger tasks, the team lead may request a random pinger selection. The only randomization is the selection of the first task(s) marked with a pinger, the second task(s) will always be the other task(s) marked with a pinger.  If the vehicle obtains any points from the first task(s), associated with the random pinger, bonus points are awarded.  At any time after the vehicle has obtained points from the task(s) associated with the random pinger, the team lead may ask to switch the pinger.  If the vehicle obtains any points from the second task(s), associated with the random pinger, bonus points are awarded.  If the team lead requests to switch the pinger before the vehicle has acquired any points, the run reverts back to a specific pinger request run and no random pinger points will be awarded.

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

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

## 3.2   Awards
Awards are provided in three categories: Design Documentation, Overall Final Standings (combines Autonomy Challenge and Design Documentation scores) and Judges' Special Awards.

### 3.2.1   Final Standings
Teams are awarded prize money reflective of their overall ranking after scores are calculated. The Autonomy challenge and Design Documentation scores are combined for the final standings. 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

*RoboSub 2023*                                                    *www.robosub.org*

## 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 no 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 semi-final performance period stops when the official touches the vehicle and continues its countdown once the vehicle is safely back at the starting location, or the team establishes communication with the vehicle, whichever is first (i.e. if a team has wireless communication with the vehicle, the countdown clock 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:** 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 RoboNation. 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.
3. Verification of kill switch operation.

### 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 their designated areas 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. (Table 3: Vehicle weight in air with Bonus or Penalties)

- **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 are 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. 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 (Table 3: Vehicle weight in air with Bonus or Penalties).
- **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 RoboSub Discord's technical-forum channel. 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 required 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% is 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 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 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 is 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:



Figure 3: Pinger timer for the four sections

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

# SECTION 5: How to Compete

*RoboSub 2023*                                          *www.robosub.org*

## 5.1    Register and Intent to Compete

All teams are required to register to compete using the Registration form found on the RoboSub website, RoboSub.org/2023. 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 2023 registration, teams must pay the registration fee of $1,250 USD. Teams are not seen as official RoboSub teams until this payment is collected. Once registered, teams are added to the team list on the RoboSub website and are eligible to request an invitation letter.

**Cancellation Policy**

In the unfortunate case that a team decides to cancel their participation, they must complete the Cancellation Form. Cancellation requests submitted via email will not be accepted. Refunds may be available dependent on the date the cancellation is submitted. Review the cancellation policy here: robosub.org/cancellation-policy.

**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 ROBOTEAM.

Access is given to teams that complete the Registration form. Only official registered teams maintain access to the Data Sharing project for the RoboSub 2023 season. The RoboSub Data Sharing platform can be accessed at robosub.org/data-sharing/access.

## 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 2023 effort, liability waivers, forms, and other contact information.

### 5.2.2    On-Site Requirements

All teams are required to submit battery specifications 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.

**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) Organization name
2) Team name
3) Shipping POC
4) Shipping POC mobile number
5) Shipping POC e-mail
6) Number of crates
7) Dimensions for each crate
8) Estimated shipping date
9) Shipping company
10) Type of shipment – Air, ground, ocean
11) Has initial pick-up or drop off been scheduled – include date of pick-up or drop off
12) Is this a dangerous good shipment?  If so, has a dangerous goods shipment been arranged?
13) Have you scheduled your outbound shipment pick-up or drop off?  Provide pick-up details (date/time) for any pick-up from the hotel.
14) Additional information for shipment, if needed.

*(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 their Design Documentation (team website, report, and video) prior to being on-site at the competition. Guidelines can be found in Section 2.3 Design Documentation.

### 5.2.6    Optional Pre-Qualification Maneuver

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 |
|---|---|
| **March 2 – ~~April 15, 2023~~**<br>***Deadline extended to April 30*** | Registration |
| **June 9, 2023** | Event Submissions Deadline:<br>• Team Information<br>• On-Site Requirements<br>• Merchandise Order |
| **June 11, 2023** | Full 100% Refund Cancellation Deadline |
| **June 16, 2023** | Design Documentation Deadline:<br>• Technical Design Report<br>• Team Introduction Video<br>• Team Website<br>• Optional Pre-Qualification<br>• Optional Community & Outreach |
| **July 25, 2023** | 50% Refund Cancellation Deadline |
| **July 31 – August 6, 2023** | RoboSub 2023 |

## 5.4 Logistics & Travel

### 5.4.1 Travel + Lodging

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

**Transportation**

Teams are responsible for their own transportation to/from the event site. Parking is extremely limited at the competition site (TRANSDEC) and the surrounding military facility. Teams will be allowed one (1) vehicle parking pass ONLY in team parking located 0.4 mile from TRANSDEC. Teams will be allowed to quickly unload/load their vehicle at TRANSDEC (5-minute max), then the vehicle must be parked in the team parking area. A shuttle bus will run between the site and the team parking area.

Teams without transportation can ride a shuttle from the Harbor Drive Annex parking lot to TRANSDEC. The Harbor Drive Annex parking lot is right across the street from the Holiday Inn Bayside.
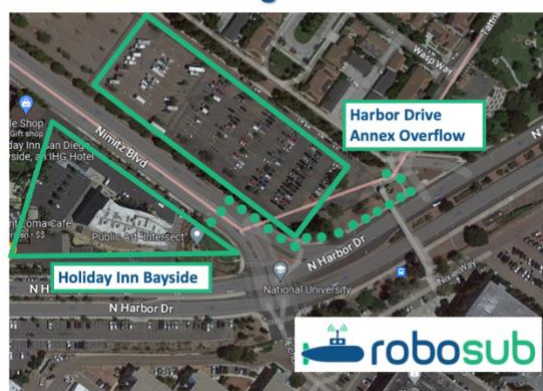
**Lodging—Event Hotel**

RoboNation has contracted with two local hotels to provide a special rate for RoboSub teams. Teams are not required to book at the event hotel; however, both hotels have agreed to open their swimming pools overnight to our RoboSub teams for practice.

1. Holiday Inn Bayside
   4875 North Harbor Drive
   San Diego, CA 92106

   - Room Cost: $239.00 plus 12.695% taxes (1-4 people / 2 queen beds) - available on a first come / first served basis / **Rooms must be pre-paid at the time of reservation.** Cancellations allowed 48 hours prior to arrival with full refund. Credit card will be required upon check-in for incidentals.
   - Reservation Cut-off: Friday, June 30, 2023.  Group Rate cannot be guaranteed if the room block is sold out or after June 30, 2023.
   - Reservation Dates Available – 07/28/23 through 08/08/23 (space available)
   - Reservation Link will be available soon.
   - Parking Costs - $10/day per vehicle
   - Overnight Pool Practice Hours - 11:00 pm – 6:00 am (07/31/23 - 08/05/23
   - Complimentary WiFi / No Resort Fees
   - Shipping Receipt/Storage - 07/28/23 - 08/07/23.  Crates must arrive no earlier than 07/28/23 and must be shipped out no later than 08/07/23 to avoid additional charges.

2. The Dana on Mission Bay
   1710 W. Mission Bay Drive
   San Diego, CA 92109

   - Room Cost: $229.00 plus 12.695% taxes (1-4 people / 2 queen beds) - available on a first come / first served basis / **Rooms must be pre-paid at reservation.**  Cancellations allowed 48 hours prior to arrival with full refund. Credit card will be required upon check-in for incidentals.
   - Reservation Cut-off: Friday, June 30, 2023.  Group Rate cannot be guaranteed if the room block is sold out or after June 30, 2023.
   - Reservation Dates Available – 07/28/23 through 08/09/23 (space available)
   - Reservation Link will be available soon.
   - Parking Costs - $10/day per vehicle
   - Overnight Pool Practice Hours - 10:00 pm – 6:00 am (07/31/23 - 08/05/23
   - Complimentary WiFi / No Resort Fees
   - Shipping Receipt/Storage - 07/28/23 - 08/07/23.  Crates must arrive no earlier than 07/28/23 and must be shipped out no later than 08/07/23 to avoid additional charges.

**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.

### 5.4.2    Shipping

Teams are responsible for coordinating the necessary shipping to ensure arrival of AUV and equipment. Any shipping questions can be directed to Cheri Koch at ckoch@robonation.org / 850.642.0536.

More shipping guidelines will be provided at a later date, once the hotel has been contracted.

**Equipment Arrival**

Teams should arrange shipments to 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 competition venue staff are not responsible for ensuring that team's outbound shipment.

### 5.4.3    On-site Logistics

**Team Village**

Each team is provided with a 10' x 10' covered working area that includes two tables, seven chairs, one electrical outlet (120V 60 Hz 15A), and a wireless internet connection. The Team Village is filled with side-by-side tents that surround the competition venue and resides on a dusty/sandy surface. Although the covered workspace is weather resistant, teams are discouraged from leaving sensitive electronics/equipment exposed in the tent.



Figure 4: US electrical outlets

Teams should conduct development, maintenance, and repair of their systems in their designated area in Team Village. 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 a designated area near each course 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.

**Vehicle Deployment and Recovery**
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. RoboSub staff are responsible for recovering any lost vehicles. All reasonable efforts to recover a lost vehicle will be made, but the recovery of a lost vehicle cannot be guaranteed. All teams recognize by entering the competition, they risk damage to, or the loss of, their vehicle.



Figure 5: Example Harness Vehicle Deployment

**Open to the Public**
This event is open to the public. Consider the high possibility that a potential future employer or sponsor may also be there to observe the event.

## 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 Forum – Now on Discord!**
All questions, comments, and suggestions should be posted on the RoboSub Forum. Teams are encouraged to actively participate in the online community and monitor it for the latest news and updates regarding all things RoboSub. Now hosted in Discord!

### 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 black "Staff" shirts.

### 5.5.3   RoboSub Website

The official competition website is www.RoboSub.org/2023. 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 autonomous 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.

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

# SECTION 6: Glossary & Acronyms

*RoboSub 2023*                                                                     *www.robosub.org*

## 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: Competition Schedule

*RoboSub 2023*                                                                              *www.robosub.org*

**Transdec Address:** 1 Transdec Road, San Diego, CA 92106
**The Dana on Mission Bay Address:** 1710 W. Mission Bay Drive, San Diego, CA 92109
**Holiday Inn Bayside:** Holiday Inn Bayside, 4875 North Harbor Drive, San Diego, CA 92106

| DATE | TIME | EVENT | LOCATION |
|------|------|-------|----------|
| **Sunday,**<br>**July 30** | | Team Travel Day | |
| **Monday,**<br>**July 31** | 4:00 pm – 5:00 pm | Team Check-in | The Dana on Mission Bay |
| | 5:00 pm – 6:00 pm | Team Orientation | |
| | 10:00 pm – 6:00 am<br>11:00 pm – 6:00 am | Overnight Pool Testing | The Dana on Mission Bay<br>Holiday Inn Bayside |
| **Tuesday,**<br>**August 1** | 7:00 am – 7:00 pm | Autonomy Challenge Practice / Qualifying | Transdec |
| | 7:00 pm | Venue Closed | Transdec |
| | 10:00 pm – 6:00 am<br>11:00 pm – 6:00 am | Overnight Pool Testing | The Dana on Mission Bay<br>Holiday Inn Bayside |
| **Wednesday,**<br>**August 2** | 7:00 am – 7:00 pm | Autonomy Challenge Practice / Qualifying | Transdec |
| | 8:00 am – 6:00 pm | Presentations / Assessments – Day 1 | Transdec – Classroom / Team Village |
| | 12:15 pm | Team Photo | Transdec |
| | 7:00 pm | Venue Closed | Transdec |
| | 10:00 pm – 6:00 am<br>11:00 pm – 6:00 am | Overnight Pool Testing | The Dana on Mission Bay<br>Holiday Inn Bayside |
| **Thursday,**<br>**August 3** | 7:00 am – 7:00 pm | Autonomy Challenge Practice / Qualifying | Transdec |
| | 8:00 am – 12:00 pm | Presentations / Assessments – Day 2 | Transdec – Classroom / Team Village |
| | 10:00 am – 2:00 pm | Media Day | Transdec |
| | 2:00 pm – 4:00 pm | Course Judge Training | Transdec – Classroom |
| | 6:00 pm | Team Meeting | Transdec |
| | 7:00 pm | Venue Closed | Transdec |
| | 10:00 pm – 6:00 am<br>11:00 pm – 6:00 am | Overnight Pool Testing | The Dana on Mission Bay<br>Holiday Inn Bayside |
| **Friday,**<br>**August 4** | 7:00 am – 7:00 pm | Autonomy Challenge  Semi-Finals – Day 1 | Transdec |
| | 6:00 pm | Team Meeting | Team Village |
| | 7:00 pm | Venue Closed | Transdec |
| | 10:00 pm – 6:00 am<br>11:00 pm – 6:00 am | Overnight Pool Testing | The Dana on Mission Bay<br>Holiday Inn Bayside |

| DATE | TIME | EVENT | LOCATION |
|------|------|-------|----------|
| **Saturday, August 5** | 7:00 am – 7:00 pm | Autonomy Challenge Semi-Finals – Day 2 | Transdec |
| | 10:00 am – 2:00 pm | SeaPerch Demo | Team Village – RoboNation Booth |
| | 6:30 pm | Team Meeting | Transdec |
| | 7:00 pm | Venue Closed | Transdec |
| | 10:00 pm – 6:00 am<br>11:00 pm – 6:00 am | Overnight Pool Testing | The Dana on Mission Bay<br>Holiday Inn Bayside |
| **Sunday, August 6** | 8:00 am – 11:00 am | Third Chance / Finalist Practice Runs | Transdec |
| | 12:00 pm – 4:00 pm | Autonomy Challenge Finals | Transdec |
| | 5:00 pm – 6:30 pm | Awards | Transdec |
| | 7:00 pm | Venue Closed | Transdec |
| **Monday, August 7** | | Team Travel Day (or Fun Day in San Diego!) | |

# Appendix B: Technical Design Report (TDR)

*RoboSub 2023*                                          *www.robosub.org*

## B.1.  Paper Preparation Overview

Each team is required to submit a TDR that describes the design of their vehicle, strategies for their approach to the competition, and rationale for design choices. Teams must follow the TDR instructions provided below.

The deadlines for the TDR and other Design Documentation submissions can be found in <u>Section 5.3</u>. To be eligible for full points, teams must submit their TDR by the deadline.

The outline of each section of the paper includes a scoring metrics table with guidance on scoring considerations that are provided to the judges during evaluations.

## B.2.  Format

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

- **6 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

***RoboNation Tip:*** It is recommended that papers be peer-reviewed prior to submission. For example, teams can utilize resources at their institution, fellow students, or professional editing services.

***Optional Formatting:*** Teams may choose to follow the two-column format, editorial style for IEEE Conference Proceedings: www.ieee.org/conferences/publishing/templates.html.

**Formatting Scoring Metrics (Maximum Points: 10)**

| | |
|---|---|
| **10 points** | Paper follows page limit, and all formatting guidelines are followed. The document is professionally organized.  All required sections are included and easy to identify.  All grammar, punctuation, and spelling are correct.  The style follows that expected of a scientific paper submitted for publication. |
| **0 points** | Formatting guidelines are not followed and the layout is unorganized. |

## B.3.  Paper Contents

The TDR consists of the following mandatory sections: abstract, technical content, acknowledgements, references, appendix A, and appendix B.

### B.3.1   Abstract

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

**Abstract Scoring Metrics (Maximum Points: 20)**

| | |
|---|---|
| **17-20 points** | Abstract is engaging, lists the scope of the work, and provides a thorough summary of the paper. |
| **13-16 points** | Abstract provides an explanation on the scope of the work and provides an adequate summary of the paper. |
| **9-12 points** | Abstract provides an explanation on the scope of the work and provides a limited summary of the paper. |
| **5-8 points** | Abstract provides a basic summary of the paper. |
| **1-4 points** | Abstract section is included but does not serve the intent of an abstract.  The abstract is treated as an introduction and provides no summary of the paper. |
| **0 points** | No abstract is included. |

### B.3.2    Acknowledgements

Participating in the competition, as in all research projects, involves leveraging 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 supported efforts is important.

**Acknowledgements Scoring Metrics (Maximum Points: 10)**

| | |
|---|---|
| **9-10 points** | Acknowledgements detail supporting personnel and their contributions as well as resources.  Sponsors and their contributions are acknowledged. |
| **7-8 points** | Acknowledgements mention supporting personnel and their contributions as well as resources.  Sponsors are mentioned. |
| **5-6 points** | Acknowledgements mention minimal supporting personnel and sponsors. |
| **3-4 points** | Acknowledgements indicate sponsors only. |
| **1-2 points** | Acknowledgements provide a general thank you but do not specify particular contributions. |
| **0 points** | No acknowledgements are included. |

### B.3.3    References

As with any technical publication, original ideas and content not generated by the paper's authors should be properly cited. The references should follow the IEEE Conference Proceedings citation style.

**References Scoring Metrics (Maximum Points: 10)**

| 9-10 points | All sources are thoroughly documented. The IEEE citation style is correctly utilized. |
|---|---|
| 7-8 points | Some sources are noted and documented.  The IEEE citation style is utilized. |
| 5-6 points | Limited sources are documented and the IEEE citation style is utilized. |
| 3-4 points | Minimal sources are documented and/or citations are not correctly listed. |
| 1-2 points | Limited sources are documented but there is no adherence to the IEEE citation style. |
| 0 points | No sources or citations are documented. |

### B.3.4    Technical Content

The technical content of the paper outlines the goals determined for the competition, and strategy for the system design and the testing approach. This portion of the paper should not include detailed descriptions of components as it can distract from understanding the team's underlying strategic thinking, design and engineering decisions, or novel contributions.

### B.3.4.1 Competition Goals

The paper must include details on the team's goals for the competition, including the plans for approaching the course and how the vehicle design relates to this approach. The course consists of multiple tasks with associated points for accomplished behaviors. The only required task is navigating through the start gates. Teams may choose to attempt the other tasks and complete the tasks in any order. The more tasks a vehicle is designed and engineered to accomplish, the more complex the overall vehicle system will be.

Consider 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. Based on history and the system engineering talents of the team, include a description the team's strategic vision.

**Competition Goals Scoring Metrics (Maximum Points: 50)**

| 41-50 points | Detailed description of the team's strategic vision and how the vehicle design compliments their goals. Detailed discussion on trade-off studies between system complexity and reliability during design development process. |
|---|---|
| 31-40 points | The team's goals are clearly evident but not discussed in detail. Trade-off studies evident but lacking details. |
| 21-30 points | Brief mention of team's strategic goals and/or trade-off studies. |
| 11-20 points | Document hints at a goal for competition and/or trade-off studies. |
| 1-10 points | Discussion of the team's vision is incoherent; rationale for competition goals is not discussed. |
| 0 points | No mention of competition goals. |

### B.3.4.2 Design Strategy

Given the strategy for success at the competition and the approach to managing complexity, the paper must include a description of the system design to meet the goals they established for the competition. Justification for design choices should be clear.  Discuss how components and sub-systems were selected and integrated on the vehicle. For teams that are working with a previously designed vehicle, discuss how the design meets the current competition strategy and any modifications needed at the component, subsystem, and/or integrated system levels. Describe the 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 Appendix B.

**Design Strategy Scoring Metrics (Maximum Points: 40)**

| | |
|---|---|
| **31-40 points** | Provides in-depth explanations on design strategy and clearly identifies creative aspects of system. Creative design methodology is justified with required calculation steps and visual aids. Content clearly exhibits a Systems Engineering approach. |
| **21-30 points** | Provides explanations on design strategy and identifies creative aspects of system. Creative design methodology is justified with calculation steps and visual aids. Content hints at a Systems Engineering approach. |
| **11-20 points** | Provides some information on design strategy and creative aspects of system. Creative design methodology is supported with a few calculations. Content could be justified as a Systems Engineering approach. |
| **1-10 points** | Provides limited information on the creative aspects of system. Creative design methodology is hypothesized. No evidence to support application of Systems Engineering principles. |
| **0 points** | Creative aspects of design are not described. |

### B.3.4.3 Testing Strategy

Testing and experimentation is a crucial step to preparing and innovating a system design that strongly correlates with a competitive performance in the arena. The paper must include the approach to a testing strategy, including various test plans, both in-water and in simulation. There is a strong correlation between in-water testing time and competitive performance in the arena.

Consider the time needed to thoroughly test to meet the determined goals. Additionally, consider the demands of design and engineering with those of testing and experimentation.

**Testing Strategy Scoring Metrics (Maximum Points: 40)**

| | |
|---|---|
| **31-40 points** | Testing approach is presented in great detail, to include test strategy and plans. Component testing, sensor and control systems testing (bench tests and in-water) done in accordance with a test plan. |
| **21-30 points** | Testing approach is presented with sufficient detail, to include test strategy and plans. Documentation shows limited components, sensors and control system testing (bench tests and in-water). |
| **11-20 points** | Testing approach is presented but not in detail. No mention of components or sensors testing. |
| **1-10 points** | Testing is done to a certain degree. No components and sensors are tested independently.   There are no test plans. |
| **0 points** | No mention of testing or connection with the system design. |

### B.3.5    Appendices

#### B.3.5.1 Appendix A: Component List

This appendix documents a list of all components utilized in the system design. In cases where components were developed by the team versus purchased off the shelf, this information should be included.  Additionally, if commercial off the shelf equipment were significantly modified this should be noted. Under the column marked "Specs" a web link to the manufacturer's specifications may be provided.  This standardized table will help document and track trends in component (hardware and software) usage and team metrics.

| Component | Vendor | Model/Type | Specs | Custom/Purchased | Cost | Year of Purchase |
|---|---|---|---|---|---|---|
| ASV Hull Form/Platform | | | | | | |
| Waterproof Connectors | | | | | | |
| Propulsion | | | | | | |
| Power System | | | | | | |
| Motor Controls | | | | | | |
| CPU | | | | | | |
| Teleoperation | | | | | | |
| Compass | | | | | | |
| Intertial Measurement Unit (IMU) | | | | | | |
| Doppler Velocity Logger (DVL) | | | | | | |
| Camera(s) | | | | | | |
| Hydrophones | | | | | | |
| Algorithms | | | | | | |
| Vision | | | | | | |
| Localization and Mapping | | | | | | |
| Autonomy | | | | | | |
| Open-Source Software | | | | | | |

### B.3.5.2 Appendix B: Test Plan & Results (Optional)

Based off the testing approach outlined in the paper, this appendix showcases the test plan that was developed and the detailed results that came out of testing. Teams should present their plans for testing, including algorithm testing in a virtual environment, component testing in a laboratory setting, sub-system testing in a relevant environment, and full system testing in a pseudo-competition environment. Test set up should be included and results presented. Any design modifications or changes in competition strategy as a result of testing should be discussed.

While this appendix is not required, excellence seen in this section can be eligible for a special judges' award.

The appendix may include detailed documentation covering the following areas:
- *Scope:* Objectives and test cases (this may also specify what was not included in tests)
- *Schedule:* Start/end dates and deadlines
- *Resource and Tools:* Resources and tools needed to conduct tests and assess results
- *Environment:* Description of the test environment, configurations, and availability
- *Risk Management:* Outline potential risks that could occur throughout testing
- *Results:* Detailed outcomes of test cases

# Appendix C: Acoustic Pinger Specifications

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The pinger type and configuration used in the competition are described in this appendix for reference so that teams may acquire a comparable unit for testing.

## C.1.  Pinger Model

The pinger selected for use is the Benthos ALP-365. This model has a selectable frequency between 25 and 40kHz with a 0.5kHz increment. It also has multiple options for repetition rate.

**Pinger specifications can be found at:  robotx.org/benthos-locator.**
*NOTE: These pingers are no longer in production and are unavailable for purchase. RoboNation is working to replace the pinger system in future competition years.*

Pingers are activated as described in the applicable task descriptions. The frequency and pulse rate of the pingers in each field may change daily; this information will be made available to teams on site. The full range of frequencies (25 – 40 kHz) and pulse rate (0.5 Hz to 2 Hz) is used throughout the competition.



Figure 6: Benthos ALP-365 Pinger

During the competition there are multiple units active at any time, with at least one in each course. To mitigate interference issues, each active pinger is separated by at least 2 kHz in frequency. The pingers are also controlled such that they send out a pulse at time intervals in sequence with the other courses.