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# Requirements & Needs Analysis

Department of Electrical & Computer Engineering

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Team: #4 RoboSub

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# Requirements & Needs Analysis

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## 1. Overview of the Design Team

### Dennis Boyd - *Lead Programmer, Web Designer*

Responsible for primary programming and overseeing all other programming. Will be responsible for helping all other programmers in the completion of their assigned tasks. Also makes final decisions (in the event of a voting tie) as to the design approach of the programming and its hierarchy. Will also assist in developing and maintaining the project webpage.

### Bjorn Campbell - *Treasurer, Electrical Systems*

Responsible for monetary allocation and management. Will also research and purchase any required parts. Design-wise, he will be responsible for power distribution inside the sub and ensuring proper heat dissipation, in addition to performing necessary circuit design, wiring, and positioning of components.

### Samantha Cherbonneau - *Programmer, Secretary*

In charge of taking group minutes during meetings and posting them to the group blog/website. Will also finalize general documents and their formatting. Responsible for designing and coding the assigned sub module(s) and providing feedback to other group programmers during the code reviews.

### Kevin Matungwa - *Programmer, Vice Team Leader*

In charge of the team's tasks in the absence of the team leader. Responsible for designing and coding the assigned sub module(s) and providing feedback to other group programmers during the code reviews. Vice team leader will also be responsible in overseeing testing.

### Elliot Mudrick - *Team Leader, Programmer, Web Designer*

Responsible for the general coordination of the team, specifically development of deadlines and the project timeline. Oversees team in meetings, both internal and with advisors. Also responsible for assigned programming tasks and assisting in general programming. Will also assist in developing and maintaining the project webpage.

## 2. Needs Analysis

### 2.1 Overview of the RoboSub

The Association for Unmanned Vehicle Systems International (AUVSI) is the consumer for this project. This organization's mission statement states that the goals of their student competitions are to "provide opportunities for students to experience the challenges of system engineering, to develop skill in accomplishing realistic missions with autonomous vehicles and to foster relationships between young engineers and the organizations developing and producing autonomous vehicle technologies." These goals align with the goals of the FSU team, and as such provide a concise statement of the team's goals.

### 2.2 Statement of the Problem

The AUVSI RoboSub competition dates for the 2015 competition have yet to be announced. Based off of last year's competition date, the estimated date for the 2015 competition is late July/early August. As this competition takes place so late in 2015, the official rules and requirements have not been released, thus this report will be based off of the 2014 competition rules and requirements. The goal of the RoboSub project this year is to qualify for and compete in the competition.

#### Required Capabilities:

- CAP-001: Run autonomously
- CAP-002: Pass through the validation gate
- CAP-003: Follow a path of orange line segments that guide the sub between tasks

#### Desired Capabilities:

- CAP-004: Bump a moored LED buoy that is alternating between Red and Green. Bump until buoy is stuck on green. Then bump a regular red buoy, followed by the regular green buoy.
- CAP-005: Maneuver around/over PVC by passing over the horizontal section, to the left or right of the center Red riser and inside the outer Green risers.
- CAP-006: Drop one marker in a bin with the primary alien target, and one marker in a bin with the secondary alien target.
- CAP-007: Fire a torpedo through a small hole in a target.
- CAP-008: Remove a red power pin that is a steel washer attached to a blue circle by a magnet, and then place the washer back in it's original position.
- CAP-009: Capture one or more Mars rocks (red) or cheese blocks (green) and deliver them to the Sample box.
- CAP-010: Surface inside the proper PVC octagon based on which set of acoustic pingers are making sound.

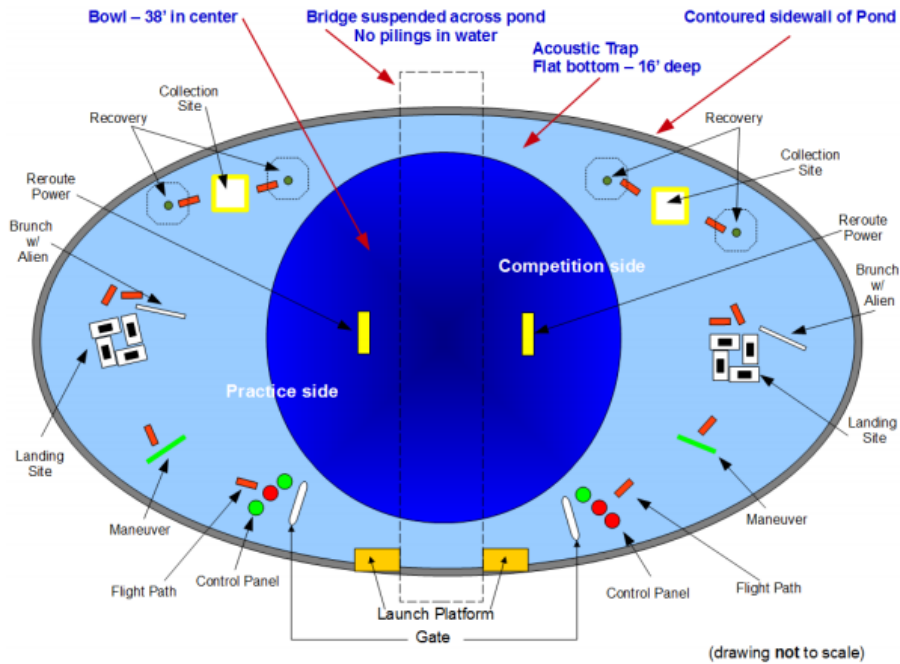


Figure 1: Competition Arena Layout

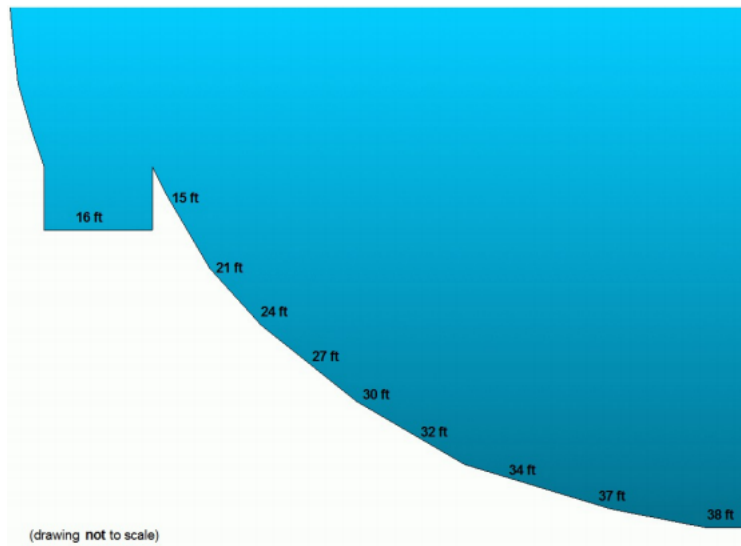


Figure 2: Competition Pool Depths

### 2.3 Operational Description

The RoboSub will be placed on the starting point and operate autonomously completing the competition objectives. The project will kick off following the objectives that were set for the 2014 competition.

## 3. Requirements Specifications

### 3.1 Functional Requirements

The following requirements list the technical specifications required by the AUVSI Foundation. These are the specification for the vehicles tasks that need completion.

- REQF-0001: Path Following. Consists of following line segments(6 inches wide) from the Gate to Control Panel, to the Maneuvering area, past the Landing Site, and finally to the landing zone.
- REQF-0002: Control Panel (Buoy). Three buoys of different colors need to be bumped. Depending on the buoy color different amount of bumps are required.
- REQF-0003: Maneuvering: The AUV will have to maneuver around a PVC with three risers.Two different paths can be chosen what given points.
- REQF-0004: Landing Site (Bins). Four bins will be used arranged in a square. The AUV can carry 2 markers to drop into the bins.
- REQF-0005: Brunch (Torpedoes firing). The AUV can fire two torpedoes at small circular cutouts.
- REQF-0006: Reroute Power. Remove a steel washer connected to a red power pin and place on an unoccupied blue circle.
- REQF-0007: Recovery Area. Remove mars rocks/cheese from the recovery area and place them in the Sample Box.
- REQF-0008: Interference. The AUV will not interfere with course components otherwise disqualification can occur.
- REQF-0009: The pingers that we will use will be Teledyne Benthos ALP-365 pingers.They can be set from 25-40 kHz in 0.5 kHz increments

### 3.2 Non-functional Requirements

The non-functional requirements are unrelated to the vehicle's performance.

- REQNF-0001: The RoboSub team should submit one 10 page journal paper. The journal paper will describe the rationale behind the design of the sub. Also a video introducing the team, the sub, as well as strategies for the competition, must be submitted.
- REQNF-0002: The RoboSub individual team members will provide updated resumes zipped to the journal paper. This is encouraged by AUVSI and a benefit to the competitors.

### 3.3 Constraints

The constraints below are limitations imposed by the rules of the 2014 competition. These restrictions will dictate how certain components and systems may be designed in order to be eligible to compete.

CONS-0001: The below table will determine the weight requirements of the AUV:

Table 1: Size and weight constraints on AUVs entered into the competition.		
	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 kg)	N/A	Loss of 250 + 5(lb – 125) 250 + 11(kg – 56.7)
84 lbs ≥ AUV Weight > 48.5 (38 kg ≥ AUV Weight > 22 kg)	Bonus of 2(84 – lb) 4.4(38-kg)	N/A
AUV Weight ≤ 48.5 lbs (AUV Weight ≤ 22 kg)	Bonus of 80 + (48.5 – lb) 80 + 2.2(22-kg)	N/A

- CONS-0002: Only one vehicle per team. Judges may disqualify a vehicle for unreasonable safety hazards.
- CONS-0003: Judges will disqualify any vehicle that pose an unreasonable risk to the integrity of the host facility.
- CONS-0004: Vehicles must operate autonomously.
- CONS-0005: All vehicles are battery powered. All batteries must be sealed. Maximum DCV will not exceed 60 Vs for the batteries or battery systems.
- CONS-0006: No materials (except for the markers/torpedoes and compressed air used to blow ballast) may be released by the vehicle into the waters of the arena.
- CONS-0007: Torpedoes must not be loaded in team tents.
- CONS-0008: For the safety of your vehicle, we require it to be slung on a harness or sling of some type.
- CONS-0009: All vehicles must have a kill switch that a diver can readily activate.
- CONS-0010: All props must have shrouds.
- CONS-0011: All vehicles must be buoyant by at least 0.5% of their mass when they have been shut off through the kill switch.
- CONS-0012: Each marker must fit within a box 2.0” square and 6” long. Each must weigh less than 2.0 lbs. Each marker must bear the team name or an emblem.
- CONS-0013: The torpedoes size, weight, markings are identical to the Markers. The torpedoes must travel at a “safe” speed.

## 4. Preliminary Test Plan

### 4.1 Capabilities Test Plan

#### 4.1.1 Path

Place orange tape in test pool and verify the sub can properly follow it.

#### 4.1.2 Control Panel (Buoy)

Get red, green, and blue LEDs fastened to a buoy (or any flotation device) which can be controlled from the surface. Verify that the sub recognizes the correct colors by manually turning off one LED and turning on another when the sub bumps the buoy in the same pattern as will be automated in the competition. Also verify that the sub can successfully bump the buoy.

#### 4.1.3 Maneuvering

Build the test gate below and ensure that the robot can maneuver it.

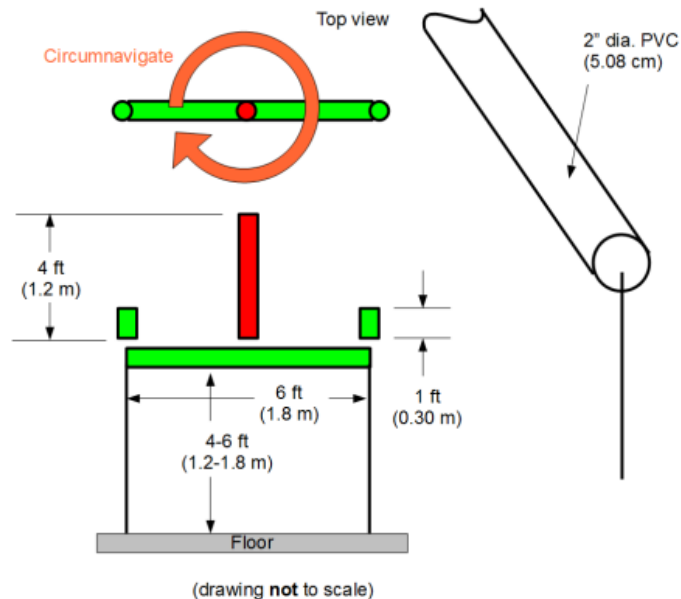


Figure 3: Maneuvering Test Gate Layout

#### 4.1.4 Landing Site (Bins)

Construct bin substitutes from duct tape, primary and secondary silhouettes for each bin respectively, and two markers to drop. Verify that the sub can drop the markers successfully. Then verify that the robot can recognize the primary and secondary targets and properly drop a marker in each.

#### 4.1.5 Brunch (Firing Torpedoes)

Verify that the sub can fire its torpedoes with sufficient accuracy. Construct a board with holes in the same design as the competition's. Ensure that the sub



can fire the torpedoes through the larger holes. Retest, covering up some holes. Verify that the sub can recognize which holes are covered and fire at the open ones. If possible, do the same for the smaller holes.

#### 4.1.6 Reroute Power (Manipulation Task)

Ensure that the robot's claw can grab and release pins. Construct a testing board as below, but with only two circles. One will have a pin and one will not, constructed in the same manner as the competition's. Verify that the robot can grab and remove the pin. Preferably verify that this pin can be replaced in the same circle. If possible, ensure the the robot can recognize the empty circle and place the pin there. Repeat this for various orientations of the two circles to verify that it can place the pin in various arrangements.

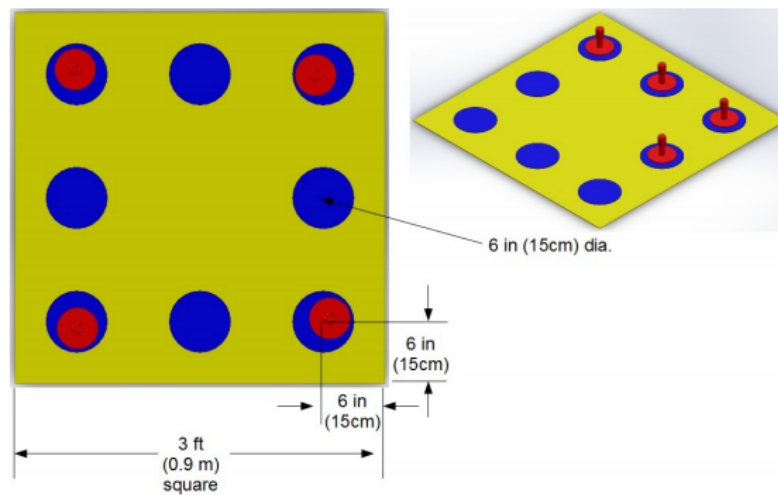


Figure 4: Pins for Manipulation

#### 4.1.7 Recovery Area

Obtain an acoustic pinger and set it to the contest specifications. Construct substitute mars rocks and green cheese, similar to shown below. Verify that the sub can recognize the pinger and head towards it. Verify that the sub can grab the mars rocks and green cheese with at least three degrees of freedom. Ensure that the robot can follow the orange tape to the collection site. Construct a test octagon floater to the competition specs and verify that the sub can surface inside of it. Verify that it can do this when guided by the pinger. Verify that it can keep hold of the rocks or cheese during this ascension and release them at the top.

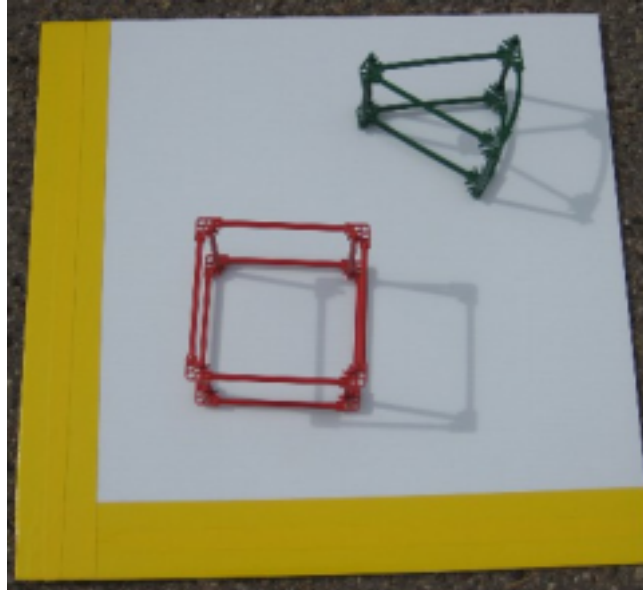


Figure 5: Mars Rock and Green Cheese

## 4.2 Constraints Test Plan

### 4.2.1 The RoboSub shall not exceed a dry weight of 125lbs

The RoboSub dry weight will be measured after all the components have been added making sure its below the weight limit. In case the 2015 competition rules requires the adding other components to the vehicle, the dead weights will be taken out to make sure that the vehicle does not exceed the weight limit.

### 4.2.2 Each marker must fit within a box 2.0" square and 6" long (5.08 x 5.08 x 15.24 cm) and weigh less than 2 lb in air.

The markers will be weighed to make sure that they don't exceed 2 lb. A tape measure will be used to measure the markers dimension to make sure they don't exceed the limit .

### 4.2.3 The Torpedoes must fit within a box 2.0" square and 6" long (5.08 x 5.08 x 15.24 cm) and weigh less than 2 lb in air and travel at a safe speed

The Torpedoes will be weighed to make sure that they don't exceed 2 lb. A tape measure will be used to measure the markers dimension to make sure they don't exceed the limit . Torpedoes speed will initially adjusted to a safe speed during multiple pool runs. Once a safe speed is visually determine, a team member will attempt to catch the torpedo as it is launched from the vehicle under water.

## 5. References

- [1] "Needs\_Requirements Template F09.pdf" Fall 2009
- [2] RoboSub\_Needs\_Analysis\_and\_Requirements\_2013. FSU RoboSub, 2013, PDF.
- [3] "AUVSI Foundation & ONR's 17th Annual RoboSub Competition: Official Rules and Mission". *RoboSub\_Mission\_Final\_2014.pdf*. AUVSI Foundation, 2014, PDF.
- [4] AUVSI Foundation Team Central Website,  
<http://www.auvsifoundation.org/competitions/robosub/robosubteamcentral>

## Appendix

### Course Requirement Descriptions

#### Path

This task consists of line segments constructed from aluminum sheet snaking their way from the Gate/Control Panel, over to the Maneuvering area, past the Landing Site and Brunch. There are two segments following the Landing Site/Brunch area, one points to the Reroute power task, and one points to the Recovery area. The "path" will be constructed of 6 inch (15 cm) wide by 4 feet (1.2 m) long sections of aluminum sheet. It will be covered with Blaze Orange Duck tape. The "path" is raised off the floor of the pool 1-2 feet (0.3-0.6 m) and each segment will not have a relative angle between two pieces of more the 90° (except for the segments which point between the path split). The segments are situated in such a way that if you follow a heading along the line segment you will (eventually) meet with the next task. The next path segment will be located on the "far side" of the obstacle 1-3 ft (0.3-0.9 m). Distances between segments will vary depending on the positioning of the tasks. The order of the tasks will always be: Control Panel, Maneuver, Landing Site/Brunch, Collection/Recovery Zone, with the Reroute power task located near the center of the facility. You may complete the tasks in any order (with the Gate required to be first before starting anything else).

#### Control Panel (Buoy)

This task consists of three moored buoys. One of the buoys will be self-illuminated with high power RED/GREEN/BLUE LEDs (RGB buoy). This RGB buoys will be 4" in diameter and approximately 15" (38cm) long (6" [15cm] lit section). Every 5 seconds it will cycle through each of these two colors: Red and Green. On the first bump from the AUV, the buoy will stop cycling. Subsequent bumps will then toggle through the colors. The two other buoys will be 9" (23cm) diameter solid color RED buoy and solid color GREEN buoy.

To receive the most point for the RGB buoy, the AUV must set the the RGB buoy to Green. For the solid color buoys, the most points are awarded for touching the Red then the Green buoy. These are two separate tasks and can be attempted each for points. The last two solid color buoys will be the ones that count for points for that portion of the task. The buoys are constructed so

that they can take a decent blow. The mooring line will either be nylon webbing or 550 paracord to minimize the chances of the vehicle becoming entangled. You may hit the buoys from any direction.

#### Maneuvering (PVC to pass over/around)

The task consists of a 2" (5.1 cm) diameter, 6ft (1.8 m) long PVC pipe with two short vertical floating risers on each end and a longer vertical floating riser in the middle. All three risers will be tied to the horizontal section and be free to move. The vertical risers on the end will be 1ft (0.3m) long tied to the horizontal section. The longer middle riser will be 4ft (1.2m) long tied to the middle of the horizontal section. The PVC is colored using Neon Green and Red Tape. There are two ways to score points. The first way is to pass over the horizontal section, to the left or right of the center Red riser and inside the outer Green risers. The second way is to circumnavigate around the center Red riser. The method and orientation of the circumnavigating vehicle is up to the team, as long as the vehicle completes a full 360° circuit of the Red riser. When attempting this method, the vehicle may extend past the outside Green risers. For either method, full points will be awarded for the center-line or more of the vehicle passing below the top of the Red riser.

#### Landing Site (Bins)

This task consists of a BLACK bin surrounded by a white border. The bins will be 1-2 feet (0.3-0.6 m) off the bottom. The four bins will be "square" array. The long side of two of the bins will be oriented with the vehicle's motion, while the long side of the other two bins will be oriented against the vehicle's motion (see Drawing 3). In each bin, there will be one Alien silhouette. A vehicle may carry up to two markers to drop within the bins. One silhouette will be designated as the primary target (only one silhouette from each column [see Drawing 8] will be in the four bins), and one will be designated as the secondary target. The most points will be awarded for dropping one marker in the primary target, and one in the secondary target. Partial points will be awarded for dropping markers in any bin.

#### Brunch (Firing torpedoes)

This task consists of a single square Green board. On the board, there will be an image of a spaceship. Above the ship are four 5in (12.7cm) circular cutouts with 7in (17.8cm) Black borders. Below the ship are two 10in (25.4cm) circular cutout with 12in (30.5cm) Black border. During a run, two of the four smaller circles and one of the two larger circles will be covered. A vehicle may carry up to two torpedoes to fire. The maximum amount of points will be awarded for firing a torpedo through each of the smaller circles. Partial points will be awarded for firing torpedoes through any cutout.

#### Reroute Power (Manipulation task)

This task consists of an array of eight Blue circles arranged on a 36in (91cm) Yellow square. There will be four Red power pins arranged on four of the eight

Blue circles. A steel washer will be glued to the back of each 4 power pin. A magnet behind each of the Blue circles will hold the steel washer on the power pin to the board. Due to the nature of the steel and magnets, do not expect the power pins to be centered on the Blue circles, see Drawing 14. Full points will be awarded for removing a power pin from one blue circle and placing it on a different, unoccupied blue circle. Partial points for removing a power pin, and more points for replacing the pin back into its previous position. Points are additive for each different pin moved.

### Recovery Area (object recovery and octagon)

This task consists of an acoustic pinger located 2 ft (0.6 m) off the floor. Floating above the pinger, on the surface will be a single octagon representing the Recovery area. The octagon will be constructed from ½" PVC pipe and have a "diameter" of 9 ft (2.74 m). Each side could have two octagons and two pingers placed in different locations. At the start of each run, one of the two pingers will be turned on. Positioned directly above each pinger will be a fixture which holds the Sample box. The top of the Sample box will be colored using Yellow Tape. Located next to the Recovery area is the 4ft (1.2m) square Collection sites with a 3" (7.6cm) border of Sunburst Yellow Duck Tape. From each of the Recovery area/pingers will be a Blaze Orange path segment pointing to the Collection site. Within the Collection site, there will be three Mars rocks (colored RED) and three green cheese structures (colored Green). The goal is for the vehicle to capture one or more Mars rock/green cheese and delivery them to the Sample box.

In order to obtain full points for surfacing, your vehicle must surface fully inside the octagon (no portion of the sub touching the structure). In order to obtain full points for recovery, the object must be captured (maintains control) by the vehicle when it surfaces. A capture consists of constraining the object in at least 3 degrees of freedom (grabbing the object with a dangling line does not count). In order to obtain full points for the drop off, the object must be released from the vehicle and sink back down (the object must first be properly recovered in order to drop it). No part of the object can be hung up on the vehicle. The team captain can choose to switch the active pinger, after the vehicle has recovered the object, but before the vehicle has surfaced. The vehicle can then transport the object to the second octagon and release the object. The competition and practice side will ping at a rate of 0.5 Hz (2 seconds), and will be separated by 0.9 seconds. The pingers will be synchronized. The schedule will be:

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

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

### Interference

Vehicles that interfere with competition elements may be disqualified at the judges' discretion. "Interference" does not include cases where, in the opinion of the judges, a vehicle is attempting to complete one of the tasks. If a vehicle becomes entangled in an objective, the run will be declared completed. Teams may keep the points earned on that run, or may have the AUV returned to the launching platform and start another new run. If a new run is begun, all points for the previous run are lost. See "Official Rules, Submissions and Fees" for more information on interference.

### Acoustics

The pingers that we will use will be Teledyne Benthos ALP-365 pingers.. They can be set from 25-40 kHz in 0.5 kHz increments

## Miscellaneous Requirement Descriptions

### Vehicle Specifications

1. Each team may enter only one vehicle into the competition. Each vehicle will be physically-inspected by the competition judges. The judges may disqualify any vehicle that they deem to pose an unreasonable safety hazard.
2. The judges will confer with representatives of the host facility, and any vehicle that, in the opinions of the judges or the representatives of the host facility, pose an unreasonable risk to the integrity of the host facility will be disqualified. The AUVSI and the host organization, their employees and agents, as well as the organizing committee, are in no way liable for any injury or damage caused by any vehicle, nor for any damage or injury caused directly or indirectly by the disqualification of a vehicle.
3. During a qualifying, semi-final or final run, each vehicle must operate autonomously during its dive. While carrying out the mission, no communication is permitted between the vehicle and any person or off-board computer. Vehicles must operate solely on their ability to sense and maneuver in the arena using on-board resources. When performing a qualifying, semi-final or final run, everything attached to the vehicle must be underwater. Any part that breaks the surface is considered a breach. During practice days and practice runs, buoys may be used on the surface for communication.
4. The weight of each vehicle must be less then the maximum allowed. Note that bonus points are awarded to vehicles that are below a certain value, and penalties assessed for those that exceed it(Table 1). The entire vehicle must fit within a box that is 6 feet long, 3 feet wide, and 3 feet deep (1.83mx 0.91m , 0.9m).

5. All vehicles must be battery powered. All batteries must be sealed to reduce the hazard from acid or caustic electrolytes. Batteries may not be charged inside of sealed vessels at any time while on the site of the competition and/or while engaged in the competition. The open circuit voltage of any battery (or battery system) in a vehicle may not exceed 60 VDC. If a team has any questions or concerns, they are encouraged to contact the organizing committee.
6. No materials (except for the markers/torpedoes and compressed air used to blow ballast) may be released by the vehicle into the waters of the arena.
7. For the safety of your team and those around you, no loaded torpedoes are allowed within the team tent. If you must test your launchers, test them either in the water, or in an open area pointing away from any other person.
8. For the safety of your vehicle, we require it to be slung on a harness or sling of some type. Even if the vehicle is light enough to hand carry, we wouldn't want anyone to slip and destroy their vehicle. Also, we need to weigh the vehicle, and require that the vehicle be slung somehow for the measurement. Please see the document Harnessing the Submarine for hints and ideas on how to accomplish this.
9. All vehicles must bear a clearly marked kill switch that a diver can readily activate. The switch must disconnect the batteries from all propulsion components and devices in the AUV. Note, this does not have to kill the computer. Upon reactivation, the vehicle must return to a safe state (props do not start spinning).
10. All props must have shrouds. The shrouds must surround the prop and have at least a 2" (5.08 cm) distance between the spinning disk of the prop and the edges of the shroud (front and back). If you have a guard across the opening, this distance can be minimal. Commercial thrusters qualify as is, as long as they are shrouded.
11. A vehicle will not be allowed in the water without a properly working kill switch and prop shrouds.
12. All vehicles must be buoyant by at least one half of one percent (0.5%) of their mass when they have been shut off through the kill switch.
13. The officials will suspend the operation of a vehicle at any time they deem that it is required by safety or security considerations. Teams may be required to submit technical descriptions of their vehicle to the officials in advance of the competition, with the goal of identifying potential safety concerns well in advance. When required, such technical information submitted to the judges will be held in confidence until the end of the competition.

## Markers

Each marker must fit within a box 2.0" square and 6" long (5.08 x 5.08 x 15.24 cm). Each must weigh no more than 2.0 lbs (0.91 kg) in air. Any marker that exceeds these limits by less than 10% will result in a 500 point penalty. Any

marker that exceeds these limits by more than 10% will be disqualified. Each marker must bear the team name or an emblem. Markers will be cleared from the arena after each run. A reasonable amount of time will be spent looking for lost markers, however consider them expendable and have back ups.

### Torpedoes

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