Task Descriptions and Specifications

2018 Maritime RobotX Challenge *www.RobotX.org*

1. Introduction

This document presents the detailed task descriptions and specifications for the 2018 Maritime RobotX Challenge, which will be conducted 08 – 15 December 2018 at Sand Island on Oahu, Hawaii. The primary landmark is the Honolulu Community College's Marine Education Training Center (METC).

The 2018 Maritime RobotX Challenge Rules and Requirements are available on the official competition website. The official competition website is www.RobotX.org. The 2018 documents posted on www.RobotX.org are the official documents for the 2018 competition. All documents referenced here and in other RobotX documents are also available at the official competition website. These documents are updated regularly. Teams are responsible for checking the website for the most recent revisions.

The term **AMS** will be used through this document to mean the Autonomous Maritime System (AMS) and any ancillary (offboard) subsystems used to accomplish the tasks. It will be necessary for teams to develop a System of Systems (SoS) consisting of systems and subsystems operating in multiple domains. All teams must use the Wave Adaptive Modular Vessel (WAM-V) surface craft, but will also need the ability to sense and act underwater. This may be accomplished by incorporating an underwater vehicle into the system to act as an off-board sensor.

2. Goals

The purpose of the RobotX Challenge is to enhance the community of innovators capable of substantive contributions to the domain of autonomous, unmanned, multi-domain vehicles. This enhancement is achieved by providing a venue and mechanism whereby the practitioners of the autonomous vehicle community may form new connections and collaborations, increase their proficiency and inventiveness, and foster their passion for robotics and the maritime domain.

This competition is designed to promote student interest in autonomous robotic systems operating in the maritime domain, with an emphasis on the science and engineering of cooperative autonomy. In addition, the competition should facilitate the building of international relationships among students, academic institutions, and industry partners to advance research in maritime autonomy.

The Maritime RobotX Challenge is a capstone robotics competition which builds upon the successful implementation of other student robotics competitions such as RoboBoat and RoboSub. We encourage student teams to participate and learn from other competitions, and then apply those skills to the advanced challenges presented in the RobotX Challenge. RoboBoat and RoboSub are annual events that can serve as test beds for future RobotX Challenges.

3. Competition Structure

3.1. Overall Approach

The competition is structured to include several autonomous performance challenges and technical documentation and communications requirements. The latter requirements provide an opportunity for teams to present their work to the judges and explain their design philosophy. Details of these requirements are given in the RobotX Project Deliverables and Presentations section.

Teams must remain on site at the competition venue at all times during the Maritime RobotX Challenge to be eligible for prizes.

The venue is large enough to support installation of multiple instances of each task in which teams may practice and qualify for spaces in the Semi-finals round. An example of the overall competition area is shown in Figure 1. Note that the following caveats apply:

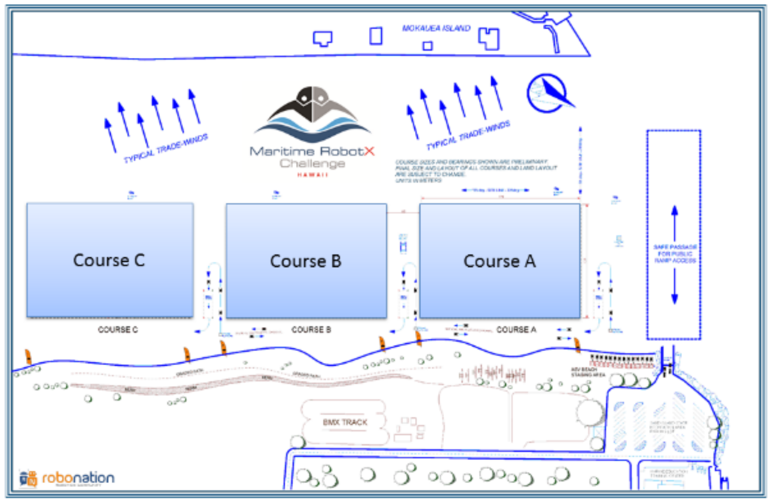


Figure 1. Planned RobotX Challenge Layout

- Sizes and bearings shown are preliminary.
- Final size and layouts are subject to change.
- Dotted lines shown are for the purpose of identifying tasks and courses on the drawing. They do not represent anything physical that will be present on or under the water.

The tasks provide opportunities to showcase the performance of the AMS by autonomously completing a range of challenges designed to represent real-world research and applications.

3.1.1. Challenge Courses (Practice / Qualifying Areas)

There are multiple instances of each task element organized as sets of tasks, referred to as **Challenge Courses**. Teams will have time slots during which they may demonstrate proficiency to qualify for the Semi-finals Round..

The practice / qualifying area will be set up along the shore and in the water. Challenge Courses will be arranged such that multiple teams may practice or qualify at the same time.

Once a team has successfully demonstrated proficiency on individual tasks of the Challenge Course, they will be qualified for the Semi-finals round and become eligible to sign up for time slots on a **Competition Course**.

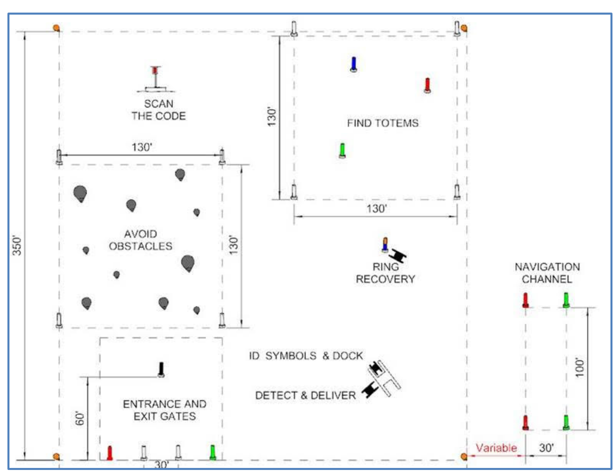


Figure 2. Example Challenge Course Layout

The practice/qualifying areas will be available throughout the competition on an assignment basis. The schedule will be presented to teams during the on-site orientation.

3.1.2. Competition Courses (Semi-finals and Finals)

Individual tasks, when clustered together, shall be referred to as **Competition Courses**. For the Semi-finals, at least one of the Challenge Courses will be converted to a Competition Course. On a Competition Course the AMS must demonstrate the ability to collect and use information from individual tasks to complete other tasks. During the Semi-finals and Finals rounds successful completion of the full course will require the AMS to use information from multiple task elements.

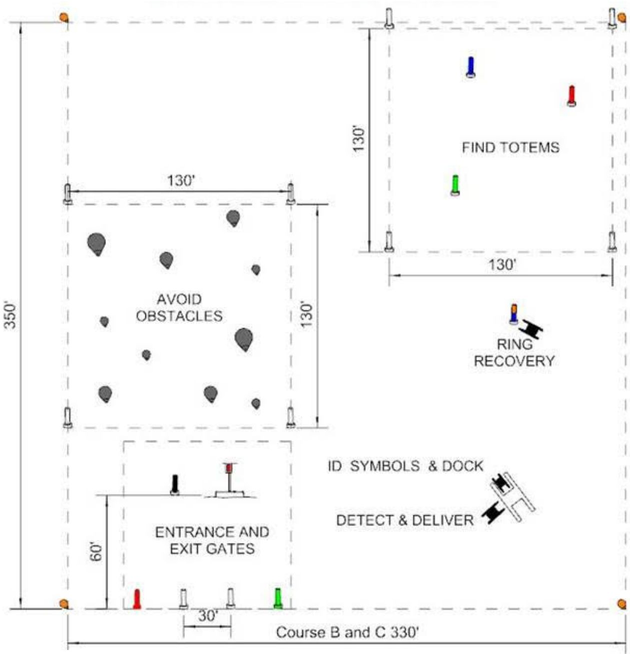


Figure 3. Example Competition Course Layout

3.1.3. 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 RobotX staff. Teams who do not have members fluent in English should contact RobotX staff as soon as possible.

3.2. Planned Sequence of Events

This section summarizes the main events of each day of the 2018 Maritime RobotX Challenge.

3.2.1. Competition Phases

There are three (3) phases to the 2018 Maritime RobotX Challenge:

- During Practice and Qualifying, teams will be given time to assemble and test their unmanned systems, participate in initial safety inspections, practice, and qualify for Semi-finals in the water on the Challenge Courses.
- During the Semi-finals Round, teams will have the opportunity to advance to the Finals Round by completing runs on the Competition Courses. Only teams that have qualified for the Semi-finals will have access to the Competition Courses. Teams that have qualified for the Semi-finals may also continue to use the Challenge Course for practice on individual tasks.
- The Finals Round will be held on **Saturday, 15 December 2018**.

3.2.2. Daily Events

Each day will start and end with a MANDATORY TEAM MEETING conducted by the Technical Directors. At a minimum, TEAM CAPTAINS are required to attend. All participants are strongly encouraged to attend.

During the morning meetings, the TD will present the plan of the day; Teams will have an opportunity to provide feedback and ask questions.

During the evening meetings, the TD will summarize the day's events and teams will be encouraged to provide feedback. It is likely that at the evening meetings, teams will have an opportunity to sign up for or trade time slots for the next day's competition events. Course changes for the following day will be described at the evening meeting.

3.3. Judging and Scoring Guidance

Detailed task scoring breakdowns are in development. They will be provided in a separate document, *2018 RobotX Scoring Guidance*. Scores will be calculated by the Judges, and all decisions of the Judges are final.

3.4. Team Operations

The 2018 Maritime RobotX Challenge will be set up along the shore and in the water near the primary public boat ramp near the METC on Sand Island in Hawaii, as represented in Figure 4.

Figure 4. Overall 2018 Maritime RobotX Challenge Venue

3.4.1. Competitor's Village

Each team will be provided with a covered working area near the Marine Education Training Center (METC). This work area will have 120VAC, 60Hz power and an internet connection. The Competitor's Village resides on a flat, paved surface. This is where teams should conduct development, maintenance, and repair of their systems. Batteries may be charged during the day at Competitor's Village, but may not be left overnight.

3.4.2. Team Operating Areas (shoreline)

Teams will be provided with an area along the shoreline near the course areas in which they will be able to set up their shore equipment. This space will consist of a tent-covered area (10 ft x 10 ft tent) with a table (6 ft long table), 120VAC, 10A, 60Hz power, and a hard-wired Ethernet connection to the TD network. The power provided is for Operator Control Station (OCS) use only, and shall not be extended to any platforms on the beach.

3.4.3. Transporting the AMSs at the Competition Venue

The RobotX organizers will provide trailers for the AMSs at the competition venue. These trailers shall be used to move the AMSs between locations on site using vehicles provided and operated by the organizers. These trailers will be used to launch and recover the AMS using the public boat ramp. Additional information regarding the trailers is available on the RobotX Forum.

3.4.4. Safety Considerations

Course boundaries will be clearly identified. The AMS must stay within the course or task boundaries at all times while attempting any tasks.

If a RobotX staff member determines that there is an unsafe condition present or imminent, that person may activate the kill switch. The RobotX staff member is not required, nor will they have time to advise the team prior to the decision to terminate the run attempt. In this and all other matters of safety, the decisions of the RobotX staff are final.

4. Qualifying for Course Entry

Prior to being launched into the water all unmanned systems must pass the prescribed safety inspection.

4.1. Demonstrate Navigation and Control

Teams must demonstrate the AMS can maintain positive control and effectively detect and navigate the channel markers. This **MANDATORY TASK** is a minimum requirement for course entry during practice and Semi-finals days.

4.1.1. Detailed Task Description

The AMS must successfully navigate through two pairs of red and green buoys in a fully autonomous manner, demonstrating effective control of the system. After demonstrating this capability, the AMS will be allowed to proceed to the team's assigned area.

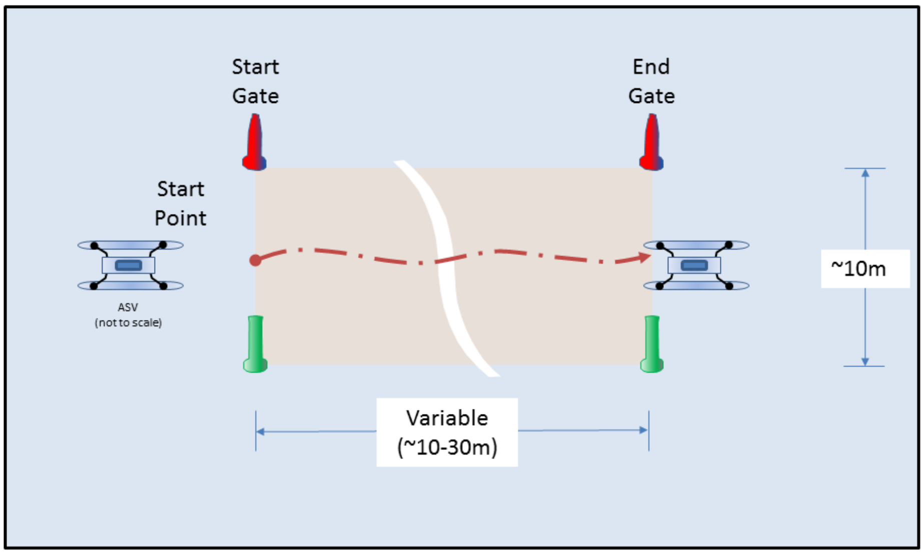


Figure 5. Demonstrate Navigation and Control

4.1.2. Task Elements

Table 1. Navigation and Control Task Elements

Task Element	Description	Model No.	Ht. Above Waterline	Tower Diam.	Base Diam.
Start Gate Port Marker	Taylor Made Products Sur-Mark Can Buoy (Red)	950410	39in.	10in.	18in.
Start Gate Starboard Marker	Taylor Made Products Sur-Mark Can Buoy (Green)	950400	39in.	10in.	18in.
End Gate Port Marker	Taylor Made Products Sur-Mark Can Buoy (Red)	950410	39in.	10in.	18in.
End Gate Starboard Marker	Taylor Made Products Sur-Mark Can Buoy (Green)	950400	39in.	10in.	18in.

4.2. Demonstrate AUV Launch and Recovery

Teams must demonstrate safe deployment and recovery of any offboard system or Autonomous Underwater Vehicle (AUV). Any off-board system must comply with all requirements detailed in the *2018 RobotX Rules and Requirements* document. Prior to being allowed to operate their AUV in the course areas, teams will be required to demonstrate safe launch and recovery of their AUV from the surface platform.

The AUV shall be tethered to the surface platform at all times.

4.2.1. Detailed Task Description

The AMS must be able to transit from its start point on shore to the course areas with the AUV onboard the surface platform. The AMS must start and end each run with the AUV in a captured state aboard the base surface platform. While performing competition challenges the AUV must be autonomously launched and recovered by the WAM-V.

Teams must verify that the AMS is capable of safely launching and recovering the AUV. This verification will consist of a visual inspection and demonstration. This safety demonstration will be conducted at a designated area. RobotX Safety Inspectors will have teams verify the function of the launch and recovery system prior to deployment of the AMS into the water. Once the AMS has been put into the water, the system will need to demonstrate the capability to successfully launch and recover the AUV in water.

The AUV will be considered successfully launched when it is free to perform its assigned mission separated from the surface platform.

The AUV will be considered successfully recovered when it is brought under positive control within the boundaries of the surface platform.

5. RobotX Challenge Tasks

This section provides details of the individual RobotX 2018 Challenge tasks. For practice and qualifying days teams will attempt the tasks individually. For the Semi-finals and Finals Rounds, the tasks may be combined into new, multi-tier tasks. Potential combinations of the tasks for the Semi-finals and Finals will be released at a later date.

Autonomous station keeping and controlled maneuvering are capabilities that enable successful completion of several tasks in the 2018 Maritime RobotX Challenge. Light contact with most course elements will be permitted; the Technical Director's team and judges may require teams to end their attempt if they determine that the AMS is in danger of damaging course elements.

5.1. Entrance and Exit Gates

A set of three gates will be located in the course area with a beacon placed underwater within each gate. The AMS must detect the active underwater beacon and transit through the gate in which the active beacon is located. Beacon specifications are available in Appendix A: Beacon Specifications.

5.1.1. Detailed Task Description

There will be four marker buoys designating the three gates: Gate 1 will be bounded by a red buoy and a white buoy, Gate 2 will be bounded by two white buoys, Gate 3 will be bounded by a white buoy and a green buoy. The AMS must detect and pass through the gate with the active beacon. The space between the ENTRY and EXIT GATE markers will be approximately 10m.

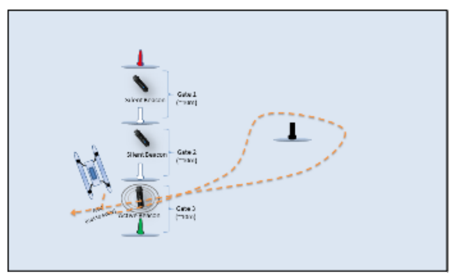


Figure 6. Entrance and Exit Gates Task

Qualifying Round

For practice and qualifying, there will be a black buoy which the AMS must circle after passing through the ENTRY Gate. After transiting through the active gate, the AMS must detect and circle the buoy in the field beyond the gates. The AMS must then return through the EXIT Gate with the active beacon. The gate with the active beacon may change between ENTRY and EXIT.

The beacon frequencies for each course will be separated by at least 2kHz and staggered in time as well as frequency. Beacon frequencies for each instance of this task will be posted daily during the competition.

Semi-final and Final Rounds

For the Semi-finals and Finals rounds, the gates will serve as entry and exit points for the Competition Courses. A single beacon will be activated at the start of each run to indicate the correct ENTRY GATE. The beacon may change during the run to indicate a different EXIT GATE. The AMS should **record the correct ENTRY gate number** for use in combination with other tasks.

The light buoy from the Scan the Code task will be located beyond the set of ENTRY GATES. Once the AMS detects the light buoy it must do the following:

1. Report the color sequence.
2. Record and display the color sequence on the team console for inspection by the judges.
3. Maneuver beyond the light buoy based on the first color displayed per the following instruction:
    a. If the first color is RED, the AMS should pass the light buoy to its STARBOARD side.
    b. If the first color is GREEN, the AMS should pass the light buoy to its PORT side.
    c. If the first color is BLUE, the AMS should circle the light buoy 360 degrees. This may be done in either a clockwise or counter-clockwise direction.

5.1.2. Task Elements

Planned task elements for this task are detailed in Table 2.

Table 2. Entrance and Exit Gate Task Elements

Task Element	Description	Model No.	Ht. Above Waterline	Tower Diam.	Base Diam.
Entry Gate Port Marker	Taylor Made Products Sur-Mark Can Buoy (Red)	950410	39in.	10in.	18in.
Entry Gate Middle Marker	Taylor Made Products Sur-Mark Can Buoy (White)	46104	39in.	10in.	18in.
Entry Gate Starboard Marker	Taylor Made Products Sur-Mark Can Buoy (Green)	950400	39in.	10in.	18in.
Exit Gate Port Marker	Taylor Made Products Sur-Mark Can Buoy (Green)	950410	39in.	10in.	18in.
Exit Gate Middle Marker	Taylor Made Products Sur-Mark Can Buoy (White)	46104	39in.	10in.	18in.
Exit Gate Starboard Marker	Taylor Made Products Sur-Mark Can Buoy (Red)	950400	39in.	10in.	18in.
Buoy to Circle Around	Taylor Made Products Sur-Mark Can Buoy (White) with black/yellow cover	46104	39in.	10in.	18in.

5.2. Avoid Obstacles

5.2.1. Detailed Task Description

For this challenge an obstacle field will be marked by four white buoys (listed in Table 3) around an area approximately 40m x 40m. The obstacles will be placed inside this area. The AMS must transit across the field without striking an obstacle. The AMS should attempt to avoid all obstacles encountered along its transit route.

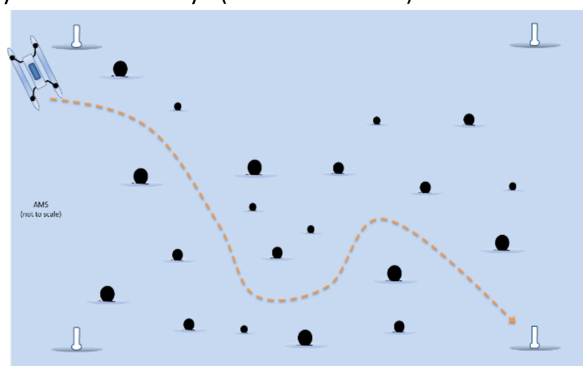


Figure 7. Obstacle Avoidance Challenge

Qualifying Round

For the Qualifying Round the transit must start near one of the boundary markers and transit to the marker buoy diagonally across from the starting buoy.

Semi-final and Final Rounds

For the Semi-final and Final rounds, the AMS must transit across an obstacle field, and may do so in the following manners:

1. The AMS may start near one of the boundary markers and transit to the marker buoy diagonally across from the starting buoy.
2. Alternatively, the AMS may transit the obstacle field in a 'lawnmower pattern' per the following description. The AMS enters the obstacle field from one edge of the obstacle field and transits across the field to the opposite side of the obstacle field. After reaching the far side of the obstacle field, the AMS may exit the boundary of the obstacle field and execute a 'U-turn', then re-enter the field and transit back across the obstacle field on a unique travel path. In other words, the AMS may not retrace its path through the obstacle field. In the lawnmower pattern the AMS may go back and forth across the obstacle field multiple times, but each crossing must be through a unique path. To score points executing the lawnmower pattern, the AMS must make at least two full crossings of the obstacle field.

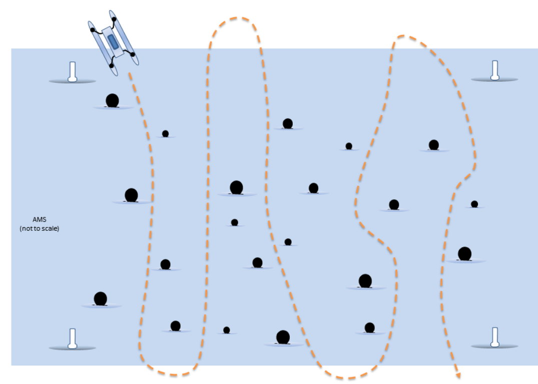


Figure 8. Example Mow the Lawn Pattern
(Note that the AMS departs the field between transits)

5.2.2. Task Elements

The task elements used for this task are listed below.

Table 3. Find Totems and Avoid Obstacles Task Elements

Task Element	Description	Model No.	Ht. Above Waterline	Tower Diam.	Base Diam.
Obstacle Field Boundary Marker	Taylor Made Products Sur-Mark Can Buoy (White)	46104	39in.	10in.	18in.
Obstacle – Small	PolyForm A-3 Black Buoy (17")	A-3 Black			
Obstacle – Medium	PolyForm A-5 Black Buoy (27")	A-5 Black			
Obstacle – Large	PolyForm A-7 Black Buoy (39")	A-7 Black			

5.3. Find Totems

5.3.1. Detailed Task Description

The Find Totems task requires the AMS to locate and completely circle distinct objects, representing traditional Hawaiian Tiki totems. To successfully circle the totem, the AMS must transit around the totem until it has crossed its approach path, transiting at least 360 degrees. The correct direction for a corresponding color totem is described in Table 4.

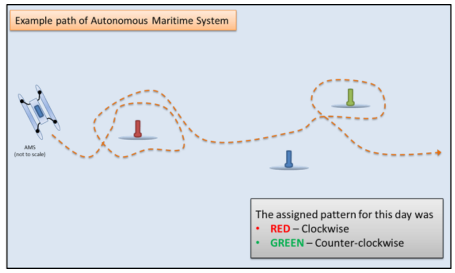


Figure 9. Find Totems

Qualifying Round

For practice and qualifying days, the totem area may be marked by four white buoys (listed in Table 5) around an area approximately 40m x 40m.

The AMS will demonstrate it has identified the object of interest by circumnavigating the correct totems in the correct direction. On practice and qualifying days the Technical Director (TD) will post the order and color totems for that day.

Figure 10. Totem Concept Image

Semi-final and Final Rounds

For the Semi-final and Final Rounds the AMS must locate the Totems and circle them in the correct order and in the correct direction. The order of execution is determined by the sequence of three colors from the Scan the Code light tower. The correct sequence to circle the color totems is given by the sequence of colors from the Scan the Code light tower.

Table 4. Totem Colors and Directions

Color	Direction
Red	Clockwise
Green	Counter-clockwise
Blue	Clockwise
Black	No points

5.3.2. Task Elements

The "Tiki totems" will rise 1-2 meters high above the water's surface. The Taylor Made White Sur-Mark Buoys will be covered by red, green, blue, or black sleeves.

Table 5. Find Totems Task Elements

Task Element	Description	Model No.	Ht. Above Waterline	Tower Diam.	Base Diam.
Totem Marker	Taylor Made Products Sur-Mark Can Buoy (White)	46104	39in.	10in.	18in.
Totem Field Boundary Marker	Taylor Made Products Sur-Mark Can Buoy (White)	46104	39in.	10in.	18in.

5.4. Scan the Code

The AMS is required to observe a light sequence displayed by an RGB buoy and report the color pattern. This is similar to the 2014 and 2016 RobotX light buoy task.

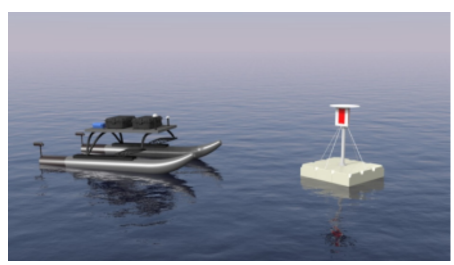


Figure 11. Scan the Code

5.4.1. Detailed Task Description

A floating platform with a vertical pole (similar to Figure 11) will be located within the search area of approximately 40 X 40 meters. The light bar atop the buoy will be no more than 3 meters above the water's surface and will display any three of the three colors: red, green, or blue. The light bar will appear black when it is off. The light assembly on the buoy will successively display colors one at a time to generate a sequential pattern of three colors (e.g., red-green-red). Each individual color will appear for 1 second, after which the lights will remain off (black) for 2 seconds before repeating the same pattern. A color may be repeated in the pattern, but the same color will not appear twice in a row.

Qualifying Round

During Practice and Qualifying days, teams will report the detected light sequence in real time using a Scan the Code graphical display as detailed in Figure 12 and Figure 12. The example Scan the Code report in Figure 13 shows the report of Red, Green, Blue for the light buoy. The Scan the Code report must be available for judges to see in the shore operations area.

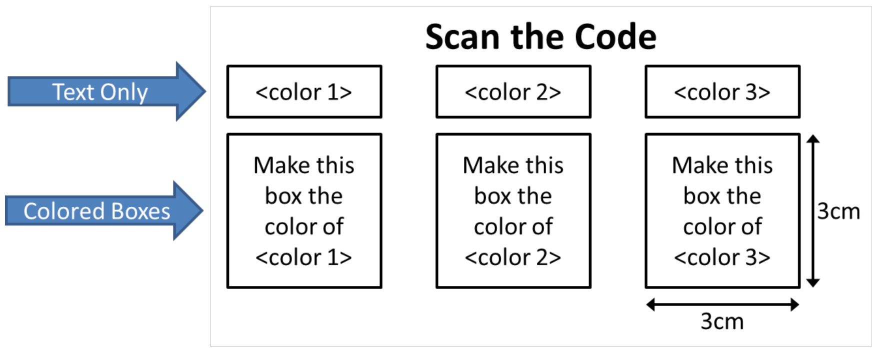


Figure 12. Scan the Code Judge's Display Specifications. (Teams must provide this.)

Semi-final and Final Rounds

In addition to providing the Judge's graphical display, during Semi-finals and Finals, the AMS will also demonstrate that it has successfully observed the light buoy by using the sequence to inform completion of other tasks. After detecting the light buoy pattern the AMS must do the following:

1. Report the color sequence.
2. Record and display the color sequence on the team console for inspection by the judges.
3. Maneuver beyond the light buoy based on the first color displayed per the following instruction:
   - If the first color is RED, the AMS should pass the light buoy to its STARBOARD side.
   - If the first color is GREEN, the AMS should pass the light buoy to its PORT side.
   - If the first color is BLUE, the AMS should circle the light buoy 360 degrees. This may be done in either a clockwise or counter-clockwise direction.

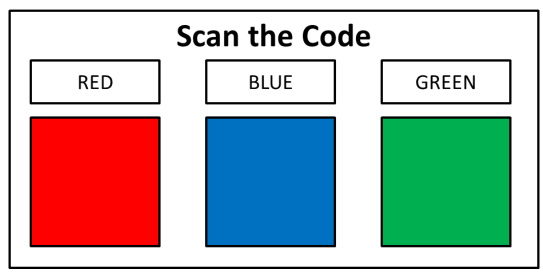


Figure 13. Example Scan the Code Report

No contact with the light buoy is permitted. Striking the buoy will result in termination of the run.

5.4.2. Task Elements

Further details of the light buoy are available in Appendix B of this document**.**

5.5. Identify Symbols and Dock

The docking task will be configured as shown in Figure 14 with symbols similar to those used in the 2016 RobotX Challenge. Dock materials are described in Table 6.

5.5.1. Detailed Task Description

The AMS must demonstrate the ability to successfully dock in bays identified by a symbol. The symbols may be red, green, or blue in color and may be in the shape of a circle, triangle, or cruciform on a white background.

The task will consist of two identical docking bays arranged as depicted in Figure 14. The dock will be anchored in a fixed location, with the symbols affixed at the closed end. Each bay consists of floats positioned to form a cul-de-sac with sufficient clearance on both port and starboard sides.

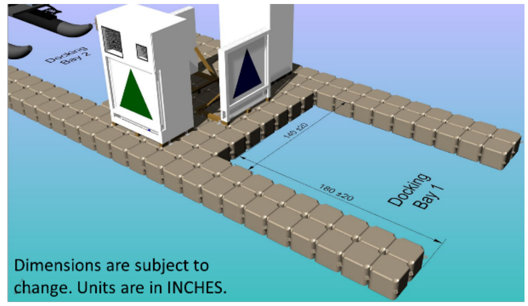


Figure 14. Docking Bay Details

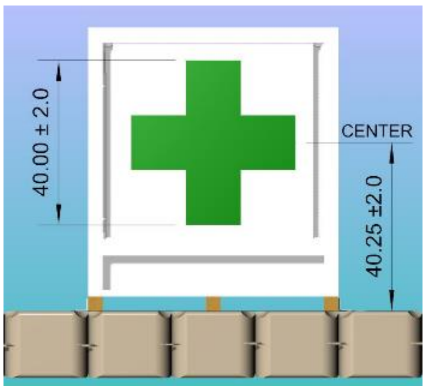


Figure 15. Front View of Docking Symbol
(Units are INCHES. Dimensions are subject to change.)

A large white placard with the symbol will be affixed to each docking bay as shown in Figure 15. The symbols will be at least 1m across on the white background, and may not be precisely centered in the docking bay. During the Practice and Qualifying days the Technical Director will designate a symbol of the day for the docking task.

The symbol placards may be randomly moved from one docking bay to another at any time during each day of the competition. There may be multiple placards with the same color but a different shape. There may be multiple placards with the same shape but a different color. Once a team begins their time slot, the position of the symbols will remain fixed throughout that time slot.

Qualifying Round

When the AMS approaches this task, it must identify the symbol for that day, and enter the docking bay that displays that symbol.

Identify Symbols & Dock and Detect & Deliver are physically located on the same floating platform. For the Practice and Qualifying days teams will be required to attempt points on each task independently. Only one team will be assigned to the floating platform during a timeslot.

Semi-final and Final Rounds

For the Semi-final and Final rounds, the AMS must demonstrate successful docking in both docking bays as described below. A docking attempt is considered successful if the AMS fully enters a docking bay between two of the adjacent pontoons. A docking attempt in which the AMS straddles a pontoon will be considered unsuccessful.

The AMS may select either docking bay in which to dock first. Based on the shape of the symbol in the docking bay, the AMS must execute a station keeping demonstration per the following:

- Triangle: 5-10 seconds
- Circle: 15-20 seconds
- Cruciform: 25-30 seconds

The AMS should hold station for no less than the minimum amount of time, nor more than the maximum time per the above description. A course judge will determine the time of each station keeping demonstration. The AMS should then depart the docking bay. The station keeping demonstration is considered at an end when the AMS begins its departing maneuver.

After the station keeping demonstration, the AMS must successfully dock in the remaining docking bay. No station keeping demonstration is required on the second docking bay.

5.5.2. Task Elements

The docks for this task will be constructed from Jet Dock assembly cubes (size large). The Jet Dock System is made from Ultra High Molecular Weight High Density Polyethylene Plastic. Jet Dock Large Cubes are 20” X 20” square by 16” tall. Jet Dock Large Cubes weigh 14 pounds each, and have 3.7 cubic feet of volume.

Table 6. Task Elements for Identify Symbols & Dock and Detect & Deliver

Task Element	Description	Manufacturer	Example Image
Dock Material	CUBE - LARGE (BEIGE) Item code: C000000008	Jet Dock www.jetdock.com	

5.6. Detect and Deliver

The Detect and Deliver task will be configured as shown in Figure 16 with symbols similar to those used in the 2016 RobotX Challenge. The dock material to be used will be the same as what is used for the Identify Symbols and Dock task, listed in Table 6.

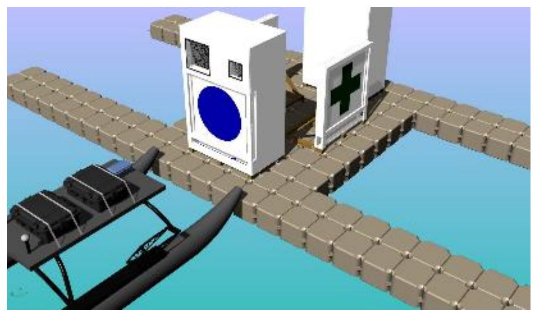


Figure 16. Detect and Deliver Structure

A floating platform will be tethered in an open area. A symbol and a pair of square target holes, one small and one large, will be visible on two opposite faces of the platform. The symbols may be red, green, or blue in color and may be in the shape of a circle, triangle, or cruciform on a white background. The AMS must propel or insert objects described in Table 7. through the target holes on the correct platform face. During practice and qualifying days the TD will designate the symbol of the day.

5.6.1. Detailed Task Description

For each run, teams will be provided with four (4) balls described in Table 7. The AMS must detect the correct symbol on the target face. The target symbol will be at least 1m across. Once detected, the system must place or launch the balls into one of the two target holes on the upper part of the floating platform. There will be two holes, one larger than the other, each outlined in black on a white background. The larger hole will be a square 0.5m on a side, and the smaller hole will be a square 0.25m on a side. Figure 17 depicts a concept drawing of the DETECT AND DELIVER task. For the Semi-finals and Finals, this task will be paired with the Identify Symbols and Dock task as depicted in Figure 16, and the correct symbol may be determined by the AMS successfully completing other tasks.

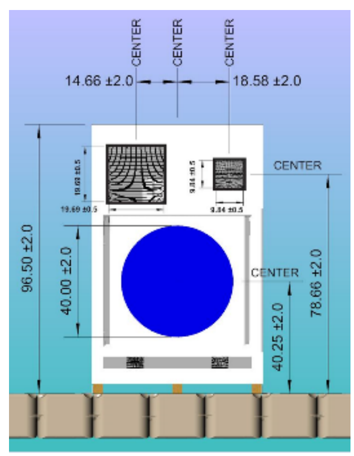


Figure 17. Detect and Deliver
(Units are INCHES. Dimensions are subject to change)

Qualifying Round

Detect & Deliver and Identify Symbols & Dock are physically located on the same floating platform. For the Practice and Qualifying days, teams will be required to attempt points on each task independently. Only one team will be assigned to the floating platform during a timeslot.

Semi-final and Final Rounds

For the Semi-final and Final rounds, the AMS may place up to four racquetballs into any of the holes on either face of the Detect and Deliver Task. A point multiplier will be applied for placing balls through the holes in the correct face. The correct face is defined as the face displaying the correct symbol. For the Semi-final and Final Rounds, the correct face is the face which displays the same shape as the shape displayed in the docking station where the AMS first docks.

5.6.2. Task Elements

Table 7. Detect and Deliver Task Elements

Task Element	Description
Blue Projectile	Penn Ultra-Blue Racquetball

5.7. Underwater Ring Recovery

The AMS must recover rings suspended underwater in the competition field.

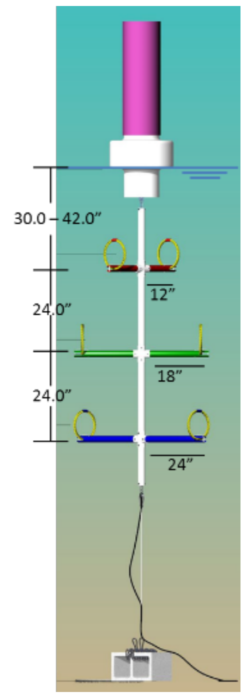


Figure 18. Ring Recovery Side View

5.7.1. Detailed Task Description

For this task rings will be attached at varying depths to a PVC structure suspended underneath a marker buoy on the water's surface. The rings will be secured at three levels, with the top tier starting 30-42" below the water surface. The middle tier will be placed 24 inches below the top tier, and the bottom tier will be placed 24 inches below the middle tier similar to the image in Figure 18. Each tier will be offset by 45 degrees from the tier above as shown in Figure 19. The tiers will be colored red, green, and blue from top to bottom.

The rings will be similar in size to each other, made from yellow polypropylene rope, and marked with colors to indicate the tier from which they were recovered. Rings will be positively buoyant.

The AMS will demonstrate completion of this task by recovering a ring to the surface platform. The ring must be secured by the AMS to be considered successfully recovered.

Qualifying Round

To qualify on this task, the AMS must recover at least one ring to the surface platform. The ring must be secured by the AMS to be considered successfully recovered. For the Qualifying Round, Launch and Recovery of a tethered AUV system is not mandatory. This allows teams that do not have a separate deployable underwater system to qualify on this task by demonstrating autonomous perception and mechanical actuation.

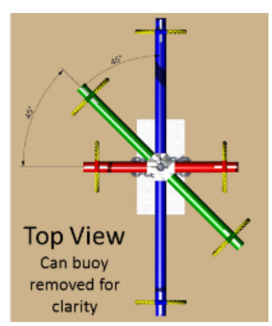


Figure 19. Ring Recovery Top View

Semi-final and Final Rounds

During the Semi-final and Final Rounds, the AMS may retrieve the rings either by using a tethered underwater vehicle or a mechanical arm or other device that is not detached from the surface platform. Points may be scored for successfully launching and recovering an underwater vehicle from the surface platform. The AMS may recover rings from any of the three levels.

5.7.2. Task Elements

A reference buoy will be visible above the water's surface. It will have a distinctive pattern on it to distinguish it from other buoys in the Challenge Course fields.

Table 8. Underwater Ring Recovery Task Elements

Task Element	Description	Model No.	Ht. Above Waterline	Tower Diam.	Base Diam.
Reference Buoy	Taylor Made Products Sur-Mark Can Buoy (White) with pattern	46104	39in.	10in.	18in.
Ring Fastener	Utilitech Nylon Cable Tie, 175lb rated	https://www.lowes.com/pd/Utilitech-15-Pack-36-in-Nylon-Cable-Ties/50005760			
Ring Structure	1.5" Schedule 80 PVC Pipe				
Ring Color Marker	Scotch #35 Electrical Tape				

The rings are made from ¾" yellow, 3-strand polypropylene rope and color coded using Scotch #35 electrical tape. The rings are 8.25" – 8.75" in diameter, and are positively buoyant. The color of the ring recovered may be used as input to guide completion of other tasks during the Semi-finals and Finals rounds.

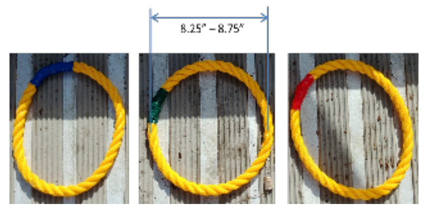
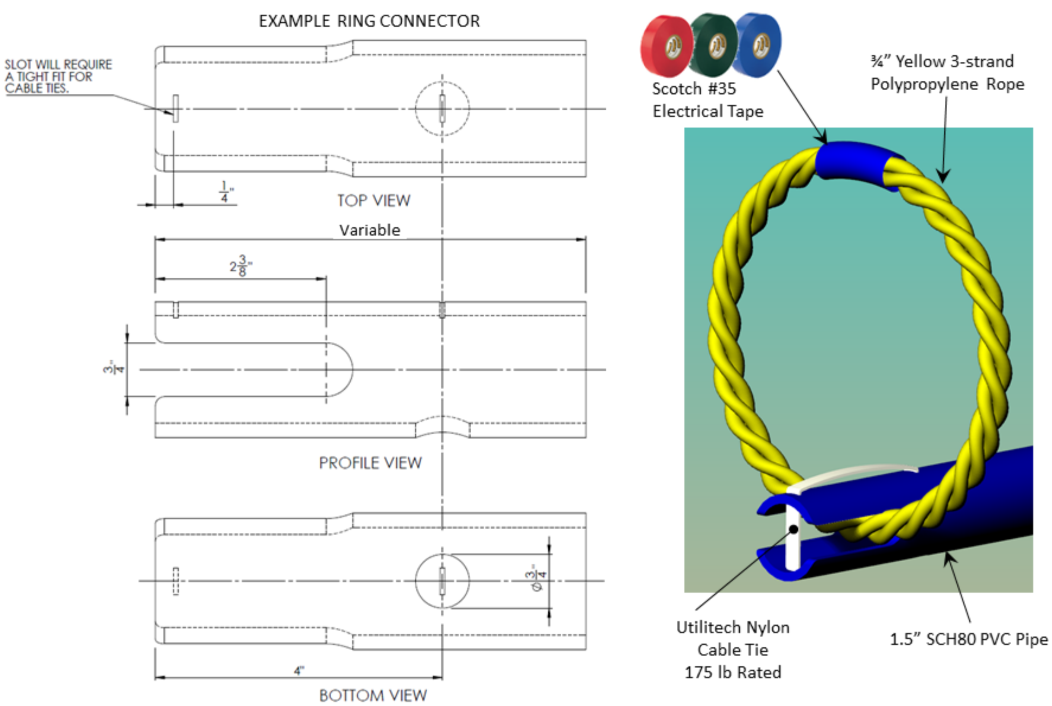


Figure 20. Polypropylene Rings

The method of attachment for the rings to the bars on each tier is shown in Figure 21.



Dimensions are approximate and may differ at the time of the event.

Figure 21. Close-up of Ring attachment method.

5.8. Situational Awareness Reporting Task

Situational awareness is an integral component of unmanned systems. Understanding an unmanned system's intent is critical in building operator trust. The *2018 RobotX Communications Protocol* (see Appendix C) provides a standardized protocol through which heartbeat and task information may be communicated to judges and TD staff.

Any task described in *Appendix C: 2018 RobotX Communications Protocol* may be reported using the guidance provided there.

6. RobotX Project Deliverables and Presentations

Each team shall design a Website, write a Technical Design Paper, create a Team Introduction Video, conduct an oral presentation, and present their System for inspection. Each team is responsible for ensuring all deadlines are met by the specified date. A Dropbox folder has been set up for each team participating in the Challenge.

6.1. Technical Submission Package *(Due 26 November 2018)*

The Technical Submission Package and Design Presentation Tasks comprise a critical element of the competition. Scores from this element will be used as a tie-breaker, if needed. Special prizes may be awarded in several categories.

6.1.1. Website

Teams must maintain a website documenting their efforts and progress leading up to the competition. The website should include at a minimum the following information:

- Team information (name and team contact information)
- Team member information (name, picture, contact information)
- System design approach
- Media (pictures, video, etc.) taken during development and testing
- List of sponsors (with logos)
- Teams are encouraged to build an archive of previous vehicles and design reports

The exact layout and contents of the website are left for the teams to develop. The technical team and the judges may visit this site prior to the competition to follow the teams' progress. The website development must be complete and ready for judging by **26 November 2018**. However, teams are expected to continually update their website up to the start of the competition. Team Website URL's will be posted on the RobotX website.

6.1.2. Technical Design Paper

Each team is required to submit a technical design paper in English that describes the design of their USV autonomy system, propulsion system, and control systems, as well as strategies for their approach to the tasks. They should include the rationale for their design choices. Specific requirements for the technical design paper are provided in the documents available in the Team Dropbox folders. All teams' papers will be published on the RobotX website after the competition.

6.1.3. Team Introduction Video

Each team is required to submit a 2-3 minute video introducing their team. This video will be scored, and will be used online and onsite during the webcast. The video is not intended to present teams' vehicle design and it may not be used as part of the design presentation.

6.2. Information Package (Due 05 November 2018)

Teams are required to submit the following items to the RoboNation organizers through their Team Dropbox.

6.2.1. Team Roster

Confirm all registration information, including Official Team Name and School or Organization Name. List each individual that worked on your vehicle, along with their corresponding information. International teams, complete the additional passport and birth information to provide RoboNation with the necessary information to issue your team an official Invitation Letter. Additionally, confirm your Team Website, Social Media information and t-shirt sizes.

6.2.2. Waiver and Release of Liability Forms

In order to participate in the 2018 Maritime RobotX Challenge, each on-site team member and faculty advisor must submit a signed Photographic Release and Liability Waiver. Failure to submit these forms will result in non-participation. Forms must be collected electronically prior to the competition. Each team is required to submit all completed forms to their Team Dropbox.

6.2.3. LinkedIn Profiles

Each team member is encouraged to submit a LinkedIn profile. LinkedIn profiles will be distributed to official RoboNation sponsors, offering students the opportunity to connect with industry professionals. Each team is encouraged to submit links to Linkedin profiles in their Team Roster.

6.3. Shipping Plan

As stated in the *2018 RobotX Rules and Requirements* document, teams will be required to submit a shipping plan to RobotX organizers no later than **08 October 2018**. This is to allow time for organizers to work with teams to ensure that their systems and support equipment can be received, worked through U.S. Customs, and staged for use during the competition. A shipping plan form, shipping address, and point of contact for the RobotX freight forwarder will be provided directly to teams.

6.4. Design Documentation Presentation and Questions

Each team is required to present their sensing, integration, power, propulsion, and autonomy scheme to the Judges in the form of an oral presentation (conducted in English) with visual aids.

This component of the Challenge will include a presentation to the Judges, as well as an opportunity for the Judges to interact with the team members using a specific set of standard questions. During the presentation each team should introduce its members, discuss their AMS, any specific challenges they overcame, and their strategies for the competition.

All team members present in Hawaii must be in attendance for the design presentation.

Planned Presentation Breakdown:

- Team Video will be played first (2-3 minutes)
- Teams will conduct a 20-minute oral presentation with visual aids
- Ten (10) minutes will be allotted for questions
- Ten (10) minutes will be allotted for the Judges to interact with the team

Teams should not bring their AMS to the presentation; Judges will inspect each team's AMS at a later time during the competition days. Teams are permitted to bring their AUV or other visual aids to the Design Documentation Presentation.

6.5. System Inspection

Judges will inspect the team's AMS, assessing technical design, craftsmanship, technical innovation, and visual impact of the design. Team members should be present to answer technical questions posed by the judges during this inspection. The System Inspection schedule will be provided at the competition site.

At least one team representative must be present for the System Inspection.

Table 9. Summary of Deliverables

Deliverable	Due Date
Registration Deadline	01 September 2018
Shipping Plan	08 October 2016
Information Package	05 November 2018
Technical Submission Package: Website, Video and Journal Paper	26 November 2018

7. Important Terms

Term	Definition
AMS	Autonomous Maritime System
AUV	Autonomous Underwater Vehicle
Challenge Course	Group of RobotX task elements organized as a set of seven tasks which teams can attempt individually to earn points towards qualifying for the Semi-finals Round of the competition.
Competition Course	A set of RobotX tasks organized as an integrated course which teams may attempt for points towards qualifying for the Finals Round. When using the Competition Course, teams must attempt multiple tasks in which the information required to complete some tasks are dependent on information gathered attempting another task.
USV	Unmanned Surface Vehicle
WAM-V	Wave Adaptive Modular Vessel

8. Change Log

This change log lists many of the most significant changes made in this revision of the Rules. It may not be all-inclusive, as minor corrections and changes may not be listed. Teams should review and understand the entire document.

Version	Changes	Date
v1.0	First release of Preliminary Task Descriptions, based on "Task Summary" document from 25 December 2017.	31 January 2018
v1.1	Updated all tasks • Entrance and Exit Gates • Scan the Code • Identify Symbols and Dock • Detect and Deliver • Underwater Ring Recovery Updated Technical Submission Requirements section	12 March 2018
v2.0	Major document revision	17 September 2018
v2.1	Integrated Beacon Specifications and Comms Protocol as Appendices Incorporated feedback from Video Call #2	27 September 2018
V3.0	Updated document to align with Scoring Document v1.0	04 December 2018

Appendix A: Beacon Specifications

Each team will need to build a localization system compatible with the competition beacon system if they are attempting underwater beacon localization tasks. The beacon type and configuration are described in this appendix so teams may acquire a comparable unit to test against if they so choose.

Beacon Model

The beacon selected for use during the RobotX competition 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.

A link to the specifications: goo.gl/DVLmqJ

Figure 22. Benthos ALP-365 Beacon

Each competition field will host a selection of beacon locations for the underwater localization challenges. Beacons will be activated as described in the rules. The frequency and pulse rate of the beacons in each field will change daily; this information will be available to teams on site. The full range of frequencies (25 – 40 kHz) and pulse rate (0.5 Hz to 2 Hz) will be used throughout the competition.

During the competition there may be multiple units active at any time, with at least one (1) in each Challenge Course. To mitigate interference issues, each active beacon will be separated by at least 2 kHz in frequency. The beacons will also be controlled such that they send out a pulse at time intervals in sequence with the other Competition Courses and Challenge Courses. Teams are advised to not rely on this to complete the challenge.

Appendix B: Light Buoy Specifications

B.1. Network Information

Description

The light buoy will consist of three faces. Each face will have an RGB matrix panel that will be used to indicate the color sequence. These RGB panels are commonly used to make the large 'Jumbotron' displays used at sports venues.

The light sequence is created by having the entire panel display one color at a time; all 3 faces will act in unison. The panel will cycle through four colors; each color will be displayed for 1 second, then the panel will go dark (no color) for 2 seconds until the pattern repeats.

This light sequence will begin once the competitor's ASV entered autonomous mode and started an operational run for points.

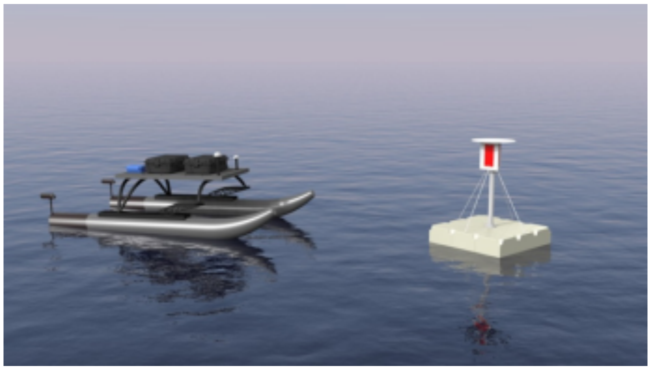


Figure 23. Light Buoy Concept

Specifications

The dimensions (in inches) of one of the three identical faces are shown to the right. The top edge of these faces will be between 3 meters (9.8 feet) and 1 meter (3.2 feet) above the water. The border around the LED panel will be white, as illustrated. The structure supporting these faces is subject to change and is not specified here.

Parts Source

The LED panels to be used for the competition buoy panels were purchased at the following link:
http://www.adafruit.com/products/420

Software that Teams may use to program and test their light panels is available at GitHub:
https://github.com/madsci1016/RobotXLightBuoy

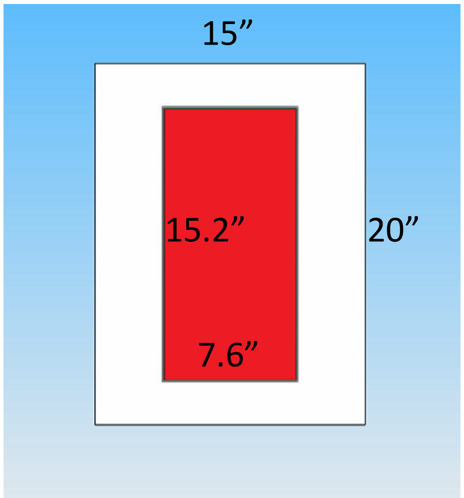


Figure 24. Light Buoy Face

Appendix C: 2018 RobotX Communications Protocol

This appendix describes the communications protocols to be used during the 2018 Maritime RobotX Challenge for the purpose of reporting vehicle status and completion of mission tasks. Each team's implementation of the requirements, outlined below, may be tested during the Challenge. RoboNation shall provide support to test this implementation prior to the RobotX Challenge.

C.1. Network Information

During operations, teams will be provided with a hard-wired connection (RJ-45) to the Technical Director's network. This connection must be used to transmit the Autonomous Maritime System (AMS) heartbeat and other reports.

When connected to the TD network, the team's computer must request an IP address from a TD Network DHCP server. Once connected, they should establish a TCP connection to a server with an address and port number, correlating to the selected course. Address and port numbers for each course will be provided during the event. A unique NMEA sentence has been defined for each challenge requiring communication between the AMS and a judge.

Teams are responsible to provide a robust and reliable data link between the AMS and the team's Operator Control Station (OCS).

C.2. General Message Information

All communication will be formatted as a NMEA-like sentence characterized by the following guidelines:

- Each message's starting character is a dollar sign.
- The next five characters identify message type.
- All data fields that follow are comma-delimited.
- Where data is unavailable, the corresponding field remains blank (it contains no character before the next delimiter).
- All dates and times are to be reported in Hawaii Standard Time (HST).
- The first character that immediately follows the last data field character is an asterisk.
- The asterisk is immediately followed by a checksum represented as a two-digit hexadecimal number. The checksum is the bitwise exclusive OR of ASCII codes of all characters between the $ and *.
- <CR><LF> ends the message.

A different NMEA sentence has been defined for each challenge requiring communication between the vehicle and a judge. The vehicle SHOULD NOT transmit any particular message at a rate more than once per second (1Hz).

C.3. Heartbeat Message

The AMS is required to transmit a heartbeat status message at a frequency of 1 Hz. This heartbeat will be used to verify the link has been established with the TD Network and competition equipment. In addition, this channel will be used to relay information specific to a challenge during its run attempt. The fields for the heartbeat message are shown in Table 10, and followed by an example heartbeat message.

Table 10. RobotX 2018 Heartbeat Message Fields

Name	Example	Description	Notes
Message ID	$RXHRB	Protocol Header	
HST Date	101218	ddmmyy	Provide date in Hawaii Standard Time (HST)
HST Time	161229	hhmmss (24hr time format)	Use Hawaiian Standard Time
Latitude	21.31198	Decimal degrees	Provides ~1.11m accuracy
N/S indicator	N	N=north, S=South	
Longitude	157.88972	Decimal degrees	Provides ~1.04m accuracy
E/W indicator	W	E=east, W=west	
Team ID	AUVSI	Team ID	5-character code assigned by TD
System Mode	2	Current mode of AMS 1=Remote Operated 2=Autonomous 3=Killed	
AUV Status	1	Current mode of the AUV 1=Stowed 2=Deployed	• The STOWED state used only when the AUV is secured to the AMS and has not yet been DEPLOYED. • The DEPLOYED state is used when the AUV has been successfully from the AMS.
Checksum	06	Bitwise XOR	
<CR><LF>		End of message	

Heartbeat Example Message: $RXHRB,101218,161229,21.31198,N,157.88972,W,AUVSI,2,1*06

C.4. Entrance and Exit Gates Message

The Entrance and Exit Gates message provides a method for the AMS to report the gate in which it detects an active beacon.

Table 11. Entrance and Exit Gate Message Fields

Name	Example	Description
Message ID	$RXGAT	Protocol Header
HST date	101218	ddmmyy
HST time	161229	hhmmss
Team ID	AUVSI	Team ID (assigned by TD)
Active Entrance Gate	1	Gate 1, 2, or 3
Active Exit Gate	2	
Light Buoy Active	Y	N = Light Buoy Off (circle Black Buoy) Y = Light Buoy On (circle light buoy)
Light Pattern	RBG	Colors identified from first to last over time R=red, B=blue, G=green Leave this field empty if the light buoy is not active.
Checksum	25	
<CR><LF>		End of message

Entrance and Exit Gate Example Message: $RXGAT,101218,161229,AUVSI,1,2,Y,RBG*25

C.5. Scan the Code Message

The Scan the Code task requires that the AMS locate and observe a buoy with a light bar to determine the light pattern displayed. The AMS must then transmit the detected light pattern using the protocol specified in Table 12. An example is provided below the table. When the AMS transmits this message the TD system will echo received message back to verify transmission.

Table 12. Scan the Code Message Fields

Name	Example	Description
Message ID	$RXCOD	Protocol Header
HST date	101218	ddmmyy
HST time	161229	hhmmss
Team ID	AUVSI	Team ID (assigned by TD)
Light Pattern	RBG	Colors identified from first to last, over time R=red, B=blue, G=green
Checksum	49	
<CR><LF>		End of message

Light Buoy Message Example: $RXCOD,101218,161229,AUVSI,RBG*49

C.6. Identify Symbols and Dock Message

The Identify Symbols and Dock task requires that the AMS identify an assigned colored shape and dock in the bay with that shape. The AMS may report the detected shape and color of the bay, in which it plans to dock, using the protocol specified in Table 13. An example is provided below the table. When the AMS transmits this message the TD system will echo received message back to verify transmission.

Table 13. Identify Symbols and Dock Message Fields

Name	Example	Description
Message ID	$RXDOK	Protocol Header
HST date	101218	ddmmyy
HST time	161229	hhmmss
Team ID	AUVSI	Team ID (assigned by TD)
Shape Color	R	Color of the shape in the docking bay R=red, B=blue, G=green
Shape	TRIAN	CRUCI=Cruciform TRIAN=Triangle CIRCL=Circle
Checksum	28	
<CR><LF>		End of message

Identify Symbols and Dock Example Message: $RXDOK,101218,161229,AUVSI,R,TRIAN*28

C.7. Detect and Deliver Message

The Detect and Deliver task requires that the AMS identify an assigned colored shape and deliver a payload into one of the holes, on the vertical surface correlating to the identified colored shape. The AMS may report the detected shape and color of the face in where it will deliver its payload using the protocol specified in Table 14. An example is provided below the table. When the AMS transmits this message the TD system will echo received message back to verify transmission.

Table 14. Detect and Deliver Message Fields

Name	Example	Description
Message ID	$RXDEL	Protocol Header
HST date	101218	ddmmyy
HST time	161229	hhmmss
Team ID	AUVSI	Team ID (assigned by TD)
Shape Color	R	Color of the shape on the face being targeted R=red, B=blue, G=green
Shape	CIRCL	CRUCI=Cruciform TRIAN=Triangle CIRCL=Circle
Checksum	32	
<CR><LF>		End of message

Detect and Deliver Example Message: $RXDEL,101218,161229,AUVSI,R,CIRCL*32