Rules and Requirements

2018 Maritime RobotX Challenge   *www.RobotX.org*

1. Introduction

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

The official competition website is www.RobotX.org. The 2018 documents posted at the official competition website are the official documents for the 2018 competition. All documents referenced here and in other RobotX documents are available at the official competition website. These documents are updated regularly. It is the Teams' responsibility to check the website for the most recent revisions.

The term Autonomous Maritime System (AMS) will be used throughout this document to refer to the entire maritime system, including the WAM-V and any off-board systems deployed from the surface platform.

2. Team Eligibility and Requirements

2.1. Eligibility

- Student teams from anywhere in the world are eligible to participate.
- Interested teams should apply using the *2018 RobotX Registration Form* found at www.robotx.org. Based on the competition venue space, the number of teams may be limited.

2.2. Industry and Student Participation

- Teams may comprise a combination of students, faculty, industrial partners, or government partners.
  - Students may be high school, undergraduate and/or graduate students. Interdisciplinary teams are encouraged.
  - Multiple educational institutions may join together to form a single team.
  - Members from industry, government agencies, or universities (in the case of faculty) may participate.
- All teams must have a member from industry.
  - The industry team member may provide any combination of technical support, financial support, other resources, or facility support.
  - Former students and team members who may have graduated and joined industry are encouraged to continue as team members and would fulfill the above requirements.

3. Platform Requirements

3.1. Surface Craft Requirements

1. All teams are required to use the WAM-V surface craft manufactured by Marine Advanced Research (MAR) (www.wam-v.com) as their primary competition boat.
2. All teams are **required to equip their WAM-V with buoyancy pods**. Examples of previously used pod designs are presented in the *RobotX Guide WAM-V Propulsion Examples* paper. Pods are also available directly from the WAM-V manufacturer.
3. Each surface craft must have at least two tow points, one set forward and one set aft. The tow points are needed to tow the AMS if it suffers a failure during course operations.
   a. The towing points must be marked with bright orange lettering, indicating a "TOW" point.
4. Given the tropical location of Hawaii, the competition efforts will continue through a potential rain shower (light or heavy) and typical wind conditions. It is therefore recommended that teams design their systems with the local tropical weather in mind.

5. Teams are required to ensure that their design does not exceed the payload capacity of the WAM-V surface platform. Basic WAM-V specifications are available on the Maritime RobotX Challenge website. Teams are advised to address basic principles of naval architecture to include considerations of centers of buoyancy, centers of mass, and metacentric height when locating sensors and other equipment on the WAM-V.

6. It is **recommended** that the surface craft have shrouds to protect the propellers from damage in the shallow waters of the operating areas.

3.2. Off-board System Requirements

1. Off-board systems from the WAM-V must be recovered back to the WAM-V.
   a. If an off-board platform is deployed to complete a task, it must be recovered prior to moving on to another task.
   b. If the off-board platform is not recovered, then the run is considered finished.
   c. This rule does not apply to the racquet balls delivered in the Detect and Deliver task.
2. Off-board systems must be tethered to the primary surface platform at all times.
   a. The tether must be securely attached to both the USV and the off-board system.
   b. The tether must be cable of withstanding the full weight of the off-board system out of the water.
3. Off-board systems to be used in water must be positively buoyant to assist in recovery.
4. **Propeller shrouds are required** for all Autonomous Underwater Vehicles (AUVs).
5. Unmanned Air Vehicles (UAVs) will not be permitted in the 2018 Maritime RobotX Challenge.

3.3. System Management and Monitoring Requirements

1. Each team's unmanned system must include an Operator Control Station (OCS) capable of controlling and monitoring the system.
   a. The OCS must have the ability to start and stop autonomous operations.
   b. The OCS must be able to operate safely aboard competition support boats, which will not have external power available.
   c. Teams are required to connect to the Technical Director's Network via the hard-wired Ethernet link, to be provided in the team operations tent. Protocols for this communication are outlined in the *RobotX 2018 Communications Protocols* appendix of the *RobotX 2018 Task Descriptions* document.
   d. Teams are responsible for providing robust and reliable communications between the OCS and AMS to attempt the competition tasks.
   e. Teams must provide a display for judges showing the results for the tasks that require reporting. This display must comply with the display requirements documented in the *RobotX 2018 Task Descriptions*.
   f. All shore-based equipment used by the team during in-water runs must be contained to the team's designated operating tent and table.
2. Teams are required to implement a clearly visible indicator on the AMS showing operational status of the AMS. Specifications for a sample indicator are provided in the *RobotX 2018 Visual Feedback Specifications* appendix of this document.
3. Teams are required to implement and provide a graphical display for use by judges as described in the *RobotX 2018 Task Descriptions* document.

4. Safety Requirements

1. Safe operations are a priority for the RobotX staff. All considerations to maintain safety for operators and the surrounding environment must be made. The following are the minimum requirements for all teams and their systems during the competition.
   a. The AMS must comply with the kill switch requirements detailed in the *RobotX 2018 Kill Switch Specifications* detailed in Appendix B of this document.
2. Before operating in the water, all unmanned systems must pass a safety inspection. This includes, but is not limited to:
   a. A Safety Judge will complete a safety checklist, verifying successful operation of all safety features **at each unmanned system launch**.
   b. During the safety inspection, teams will demonstrate compliance with all of the requirements above, to include identifying all actuators, and moving parts and their associated protection mechanisms (shrouds, etc.).
   c. Verification of both kill switches' operation (remote and physical) will be repeated each time a team enters the water.
3. 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.
4. AMS power systems must follow the safety rules and regulations of the host country as well as the team's home country.
5. RobotX staff may suspend team operations at any time for safety considerations.
6. Teams must provide battery specifications, Material Safety Data Sheets (MSDS), and proper disposal procedures, all sourced directly from the battery manufacturer. These documents must be provided as part of the teams' Technical Submission Package, described in the *RobotX 2018 Task Descriptions* document.

Appendix A: Battery Safety Requirements

Teams are required to understand and follow battery safety best practices based 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. Therefore, the safety rules and requirements outlined below must be followed to participate in the competition.

1. Students must submit a copy of their battery specifications, safety information, and safe disposal instructions for all batteries. Documents must be submitted using their Team Dropbox in accordance with the RobotX rules.
2. In addition to the online submission, Students must keep a hard copy of their submitted documentation for all batteries (lithium ion, auto / motorcycle, etc.) in their Team tents (on-site) at all times for reference.
3. Note that Li-Po (Lithium Polymer) battery packs need safety and balancing circuits and must labeled HAZMAT when shipped.
4. Each team must understand and follow both their own country's regulations as well as those of the host nation.
5. All batteries shall be stored, used, and maintained in accordance with manufacturer guidelines.
6. Students are required to inspect their batteries daily for signs of swelling, heat, leaking, venting, burning or any other irregularities.
7. 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.
8. Lithium batteries which do not hold a charge should be removed from use and reported to the Technical Director.
9. A team member must be present to monitor charging batteries.
10. At the competition site, students must immediately notify the Technical Course Director or a staff member if any of the above battery conditions are observed and must provide the battery specifications and safety information.
11. At the hotel, if a battery irregularity occurs at any time, students must notify Cheri Koch immediately by phone at 850-642-0536 and have battery specs / safety information available.
12. Failed or Failing Lithium ion batteries handled in accordance with the manufacturer's safety and disposal guidelines. This may include placing the battery in a LiPo safe bag, which will then be placed in a 5 gal bucket, covered with sand and placed in a designated safety zone.
13. Teams should review the reference documentation provided on the RobotX.org website, which includes information on batteries and battery technologies.
14. Teams will not be permitted to change or replace AMS batteries on shore near the course areas; this will only be allowed in the Team Village.

Appendix B: Kill Switch (Emergency Stop) Specifications

The Maritime RobotX Rules specify that each competing craft must have two emergency stop systems:

- a hard-wired, on-board, emergency stop system
- a wireless remote emergency stop, located off-board, operating on its unique frequency and link

These are also known as kill switches or E-Stops. The purpose of this appendix is to provide specifications and guidance so that teams can meet these requirements. Note that kill switch requirements apply to both Autonomous Surface Vehicles (ASVs) and Autonomous Underwater Vehicles (AUVs), when used as an offboard sensor.

Both systems must operate independently of the vehicle's other systems and upon activation of either emergency stop system (on-board or off-board), the switch must instantaneously disconnect power from the vehicle's thruster units. An example of how to implement this is shown in Figure 1. System should be designed such that power, to the thrusters, cannot be restored until the emergency switch is reset. This applies to both surface and underwater vehicles.

The TD staff will conduct a detailed engineering and safety inspection in which teams will be required to demonstrate proper operation of all emergency systems.

Onboard Emergency Stop

All vehicles must have an onboard emergency stop capable of being actuated by personnel from a support craft. For personnel safety, the switch may be triggered from a distance by a wooden or plastic pole/paddle for surface craft, and by divers for AUVs. Keeping this in mind, teams should select rugged and reliable components for their safety system.
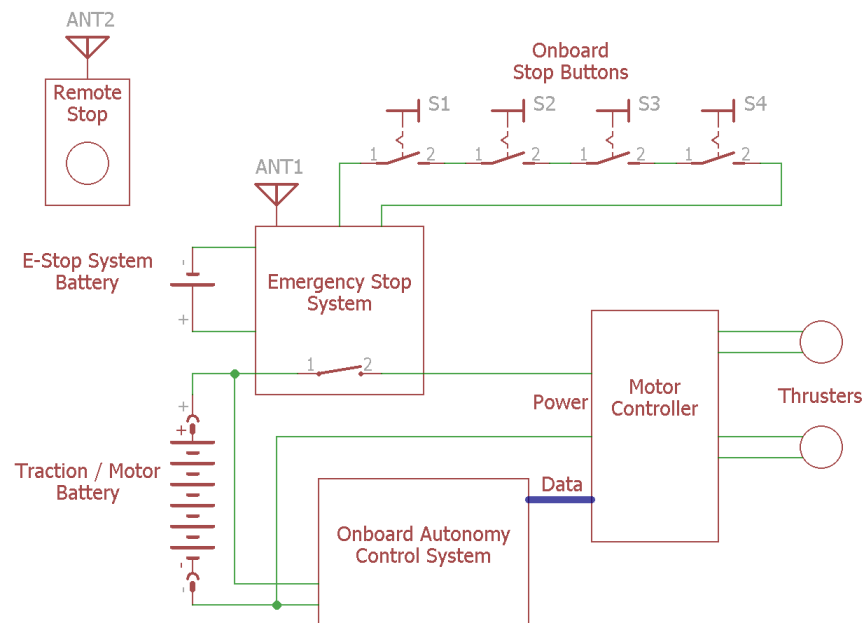

Figure 1. Sample emergency stop circuit

WAM-V Autonomous Surface Vehicle

For the WAM-V, teams will be required to place activation switches, for the emergency stop system, on each of the four arms leading from the payload deck, to the skid plate, or suspension bracket on the pontoons. Examples of acceptable kill switch placement are shown in Figure 2. This switch must be demonstrated to disable AMS thrusters within 1 second of activation in all AMS operating modes.

Figure 2. Kill Switch Placement Examples

Autonomous Underwater Vehicle

Off-board autonomous underwater vehicles should have the capability to be immobilized, allowing support teams to safely approach vehicle, when necessary.

- The AUV must be wired such that disconnecting the tether shall engage the emergency stop system.
- Both the onboard and remotely activated kill switches for the AMS must also kill propulsion power to any off-board systems such as AUVs.
- Engaging the emergency stop system shall cut power to ALL the thrusters immediately.
- If AUV is self-powered (has its own internal batteries), then the AUV must have an on-board physical kill switch that cuts power to its thrusters so that support teams can safely approach the AUV.
- Teams that elect to use a magnetic kill switch must ensure that the switch can be easily activated or pulled off at arm's length; if the switch actuator needs to be pulled off the AUV, it must be positively buoyant.

E-Stop button (for ASV)

A large, red button should be installed in such a way that safety personnel, from the support craft can easily actuate the button. The engage/disengage button should be red in color and have a press to activate and twist or pull to reset feature. This button, momentary contact switch or not, on actuation, should cut power to the thrusters immediately on actuation. The thrusters must remain in a

Figure 3. Example Kill Switch

powered-down state until the judge gives permission for the team to reinitialize the system. An example of a suitable button is shown in Figure 3. This particular switch was found at McMaster-Carr, and it can be found here: http://www.mcmaster.com/#6785k21/=rjy8d1

Wireless Emergency Stop

All vehicles must be equipped with a portable, handheld, Wireless Emergency Stop controller. This controller must immediately disconnect power to the vehicle's thruster units when actuated. It should be **independent of any software controlled functionality of the operator's station**. This includes operating on radios independent of the standard command and control system. Example: if teams are using a computer or other embedded system to relay control signals (tele-operation or autonomous mode) to the unmanned system, the emergency stop should be independent of this setup.

The on-board component of the system must operate independently of the rest of the vehicle power, control, and communications systems. This means that it should have an independent power source and use an independent RF system that does not interact or interfere with the TD network or vehicle command and control systems. In addition, this system must also meet host country RF guidelines for frequency and transmit power.

Appendix C: Visual Feedback Specifications

Teams are required to implement a visual feedback system to indicate status of the Autonomous Maritime System (AMS). Such a system is required to improve the safety of RoboNation support operations. This appendix describes a lighting system that will serve as a visual status indicator to the judges, staff, local observers and technical directors, of each team's unmanned system.

With unmanned systems being integrated into everyday use, it is safety critical for these systems to provide clear indication of their operational status to anyone in its vicinity. Resources and general guidelines outlined here may be used by teams to acquire, integrate and test a system that meets the safety requirement set forth in the safety section of the *2018 Maritime RobotX Challenge Rules* document.

Figure 4. Example Visual Indicators

Basic Requirements

The lighting system shall consist of, at minimum, three lights: Red, Amber and Green or Blue. Lights shall be arranged in a vertically arranged configuration and mounted such that they provide a **360 degree daylight visibility**, when viewed from shore or nearby vessel (approximately 150 meters).

Lighting system colors shall correspond with the applicable mode of the team's autonomous system as indicated in Table 1, below. The lights may be flashing or steady on/off according to the state of the system.

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Table 1. Light color and correlating modes

Color	Mode
Amber or Yellow	Tele-Operation / Manual Operation
Blue or Green	Autonomous operation
Red	E-Stop active (propulsion disabled)

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Several visual indicator examples are shown in Figure 4, including off-the-shelf and custom LED array approaches. Keeping the below specifications in mind, design and selection of the final system is the team's decision.

Detailed Specifications

The maximum height dimensions and diameter of the lighting system are left to the discretion of the teams, depending on the amount of additional lights they want to add. However, the minimum height of the lighting systems shall be 12.5 cm. To provide visibility in sunlight, teams should use lighting systems which have clear enclosures for the light to shine through; rather than colored enclosures with standard light bulbs. The generic versions of these lighting systems are used indoors on machines and equipment for status indication across several industries and as such, are available globally. However, for the purposes of this competition, the technical directors will require teams to procure lighting systems that are visible in sunlight and can be observable from the shore and the on-water support craft (approximately 150 meters).