Rules and Requirements

Maritime RobotX Challenge 2022 *www.robotx.org*

1. Introduction

This document presents the rules and safety requirements for the 2022 Maritime RobotX Challenge, which will be conducted 11-17 November 2022 at the Sydney International Regatta Centre, Penrith in New South Wales, Australia. Failure to adhere to the following requirements may result in your team not being allowed to compete.

The official competition website is www.RobotX.org/2022. The 2022 documents posted at the official competition website are the official documents for the 2022 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 **team's 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 Unmanned Surface Vessel (USV) and any off-board systems deployed from the surface platform, such as the Unmanned Aerial Vehicle (UAV).

2. RobotX Information and Updates

2.1 Join the RobotX Community in the Band App

The RobotX Community in the Band App was created to keep you updated on the latest announcements, resources and even some special deals throughout the competition season. We encourage each team member to download the Band App (available on Android and iOS) and get to know the other RobotX teams! Access will be provided in the registration confirmation email.

2.2 RobotX Forum

All technical questions, comments, and suggestions should be posted on the 2022 RobotX Forum. Teams are encouraged to actively participate in the online community and monitor it for the latest news and updates regarding all things RoboBoat.

3. Participation and Eligibility Requirements

3.1 Eligibility

- Student teams from anywhere in the world are eligible to participate.
- Teams are required to register using the 2022 RobotX Registration Form found at www.robotx.org.
- Based on the competition venue space, the number of teams may be limited.

3.2 Industry and Student Participation

- Teams will comprise a combination of students, faculty, industrial partners, or government partners.
  - Students may be undergraduate and/or graduate students. Interdisciplinary teams are encouraged.
  - Multiple educational institutions may join together to form a single team.
- 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 fulfil the above requirements.

4. Registration Information

To participate in the competition, all teams must register through the official RobotX 2022 website. This registration collects team contact information, an optional team bio and logo and additional information.

4.1 Fees

There is no registration fee required to participate in the Maritime RobotX Challenge.

4.2 RobotX Website

Once RoboNation has received your registration, your team will be added to the RobotX website, making you an official RobotX 2022 team.

4.3 Data Sharing Access

Once RoboNation has received your registration, the generic team email address you provided will receive access to the Data Sharing effort in the Box platform. For more information on Data Sharing, visit the Data Sharing website.

4.4 Join the RobotX Community in the Band App

Once your team registers, you will receive a confirmation email with a link to join the RobotX group on the Band App. We encourage each team member to download the Band App (available on Android and iOS) and get to know the other RobotX teams!

5. Platform Requirements

5.1 Unmanned Surface Vessel (USV) Requirements

1. All teams are required to use the WAM-V-16 USV manufactured by Marine Advanced Research (MAR) (www.wam-v.com) as their primary competition USV.
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 and student technical papers from previous events, available on the RobotX.org website. Pods are also available directly from the WAM-V manufacturer.

3. Each surface vessel must have at least two (2) orange tow points, one set forward and one set aft. The tow points may need to be used to tow the WAM-V between the boat ramp and the course area, and in the event it suffers a failure during course operations.
   a. The towing points must be marked with bright orange lettering, spelling out "TOW" to indicate the locations of the tow points.
   b. Lettering must be at least 7cm tall.
4. Whilst the competition location is normally sunny at this time of year, there is the potential for a rain shower (light or heavy) and varying wind conditions. The competition will continue through these weather conditions. It is therefore recommended that teams design their systems with these weather conditions 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 RobotX.org 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. The propellers must be shrouded for safety.
7. Teams are required to ensure their WAM-V and trailer fit under the competition tents. Additional masts are acceptable, however teams must ensure that any masts and are able to be removed or folded down to ensure tent height clearance. The maximum allowable height of the trailer + WAM-V so that it fits under the competition tent is 3028mm.

5.2 Unmanned Aerial Vehicle Requirements

1. **Note: The Australian Civil Aviation Safety Authority (CASA) refers Unmanned Aircraft as Remotely Piloted Aircraft (RPA) (commercial use) or model aircraft (recreation use). For the purposes of this document, the terms Drone, Unmanned Aerial Vehicle (UAV) and model aircraft are used synonymously.**
2. The maximum allowable model aircraft category (size) for this competition is small. This category allows model aircraft no more than 7kg. Model aircraft that weigh more than this will not be allowed to fly at the competition.
3. Current CASA model aircraft registration and operating requirements will change in 2022 and are yet to be confirmed. Further updates will be provided to teams when these new requirements are confirmed.
4. When flying it is important to ensure the following CASA Drone safety rules are adhered to:
   a. https://www.casa.gov.au/drones/rules/drone-safety-rules
5. As model aircraft will be operating above water, there is the requirement for them to be able to float in freshwater. This will enable recovery in the case of an emergency and will minimize damage to onboard systems.

5.3 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. The OCS must have the ability to remotely kill the platform as described Appendix B: RobotX Kill Switch Specifications.
    d. 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 2022 Communications Protocols appendix of the *2022 Maritime RobotX Task Descriptions and Specifications* document.
    e. Teams are responsible for providing robust and reliable communications between the OCS and AMS to attempt the competition tasks.
    f. 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 *2022 Maritime RobotX Task Descriptions and Specifications* document.
    g. 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 Visual Feedback Specifications appendix of this document. NOTE: These are **minimum** requirements.
3. Teams are required to implement and provide a graphical display for use by judges as described in the *2022 Maritime RobotX Task Descriptions and Specifications* document.

6. 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 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 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. This is detailed on the Australian Communications and Media Authority (ACMA) website and summarized in the *2022 Maritime RobotX Radiocommunication Restrictions* document.
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 Team's Technical Submission Package, described in the *2022 Maritime RobotX Task Descriptions and Specifications* document.

Appendix A: Battery Safety Requirements

Teams are required to understand and follow battery safety best practices on the battery chemistry selected by the team. Lithium-ion chemistry batteries may become damaged and create a hazard if misused/abused, representing the greatest risk to people, facilities, and the environment. 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.
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 cell level safety and balancing circuits and must be labeled HAZMAT when shipped.
4. Each team must understand and follow 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. 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 bucket, covered with sand and placed in a designated safety zone.

12. Teams should review the resource library provided on the RobotX.org website, which includes information on batteries and battery technologies.
13. 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 Unmanned Surface Vessel (USV) 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 the kill switch requirements only apply to the USVs. UAVs have separate requirements which must be met.

Upon activation of either emergency stop system (on-board or off-board), the switch must instantaneously (less than 1 second) disconnect power from the vehicle's thruster units. Further, Emergency stop systems must be operate in a fail-safe fashion. If any part of the Emergency stop system or any sub system it relies on (communication, power, etc) fails or looses connection, the switch must instantaneously (less than 1 second) disconnect power from the vehicle's thruster units. An example of how to implement this is shown in Figure 1. Systems should be designed such that power, to the thrusters, cannot be restored until the emergency switch is reset.

The Technical Director staff will conduct a detailed engineering and safety inspection in which teams will be required to demonstrate proper operation of all emergency systems. Teams must also be prepared to discuss the design and implementation of their fail-safe systems in detail, if requested.

WAM-V Unmanned Surface Vessel (USV)

Onboard Emergency Stop System

All WAM-Vs 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. Keeping this in mind, teams should select rugged and reliable components for their safety system.

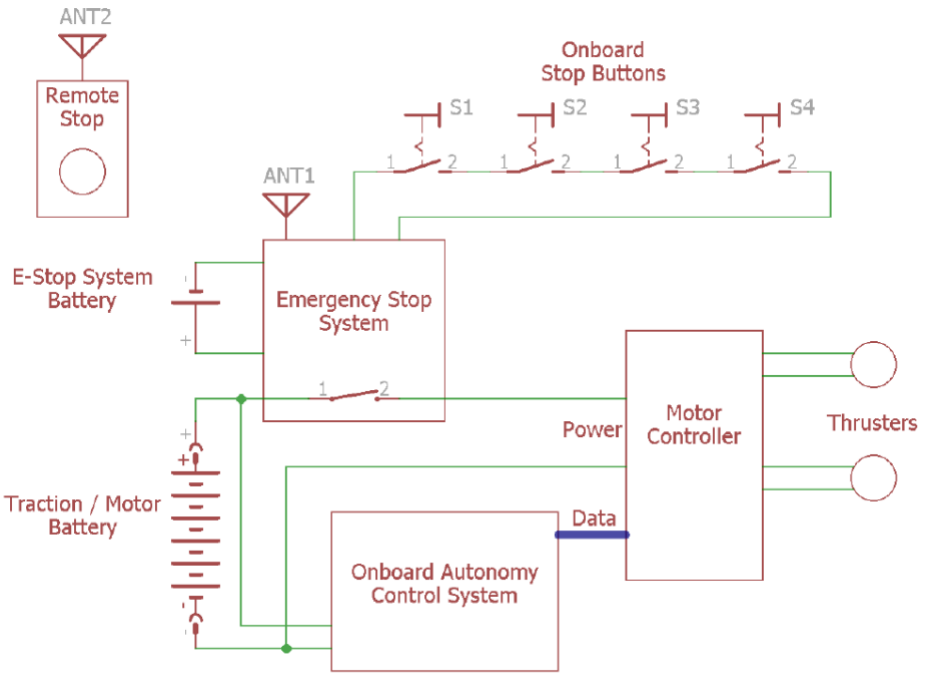

Figure 1: Example Emergency Stop Circuit

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: Examples of Kill Switch Placement

Emergency Stop Button

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 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

Figure 3: Example Kill Switch

Wireless Emergency Stop

All WAM-Vs must be equipped with a portable, handheld, Wireless Emergency Stop controller. This controller must immediately (less than 1 second) disconnect power to the vehicle's thruster units when activated. . If any part of the Emergency stop system or any sub system it relies on (communication, power, etc) fails or looses connection, the switch must instantaneously (less than 1 second) disconnect power from the vehicle's thruster units.

In addition, this system must also meet the host country RF guidelines for frequency and transmit power.

Unmanned Aerial Vehicles (UAVs)

As UAVs operate in the air and in these challenges, over water, a kill-switch would result in catastrophic damage to the vehicle and have the potential to injure people and damage the course.

Instead, all UAVs must have an emergency return-to-home function which can be operated remotely off-board, operating on its unique frequency and link. Upon activation of the return-to-home function, the UAV must instantaneously stop all other tasks, ascend to 25m above ground level, return to 'home' GPS coordinates and land.

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.

Figure 4: Example Visual Indicators

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 requirements section of this document.

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.

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)

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 Specification

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 the 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).