



# 2022

## TEAM HANDBOOK

V2.0 (February 2022)



# Introduction

Maritime RobotX Challenge 2022

www.robotx.org

## Welcome to the forefront of innovation, with the 2022 Maritime RobotX Challenge!

This Team Handbook contains the information that teams will need to compete at the 2022 Maritime RobotX Challenge. It includes task descriptions, rules and requirements, specifications and other guidance. This document will provide teams with a comprehensive understanding of what will be necessary to compete effectively.

**What is RobotX?** The Maritime RobotX Challenge is a biennial international competition hosted by RoboNation and was established to foster student interest in robotic and autonomous systems operating within the maritime environment. The RobotX competition framework challenges teams to transform the Wave Adaptive Modular-Vessel (WAM-V) into an Autonomous Maritime System (AMS), developing and integrating an Unmanned Surface Vehicle (USV) and an Unmanned Aerial Vehicle (UAV) to accomplish a series of tasks on the Autonomy Challenge course. Teams also learn the critical need to document their designs throughout the process.

**Why RobotX?** The goal of the Maritime RobotX Challenge is to expand the community of researchers and innovators capable of substantive contributions to the emerging field of autonomous and unmanned, multi-domain vehicles.

**Why compete in RobotX?** Participants of the Maritime RobotX Challenge can expect to:

- Increase technical proficiency;
- Establish valuable professional connections; and
- Enjoy the satisfaction of learning and collaborating while competing at a world-class level.

The Maritime RobotX Challenge builds upon the successful implementation of other student robotics competitions, such as RoboBoat and RoboSub. Teams are encouraged to learn from their participation in competitions such as these and apply their skills to the more advanced challenges presented in RobotX.

*Maritime autonomous technology is critical to monitoring and healing our oceans. Developing the human resource to expand this effort is even more essential.*

## 2022 ROBOTX ORGANIZERS



The 2022 Maritime RobotX Challenge is hosted by RoboNation, in collaboration with the United States Office of Naval Research (ONR), the Australian Defence Science and Technology Group (DSTG), and the Next Generation Technologies Fund (NGTF).

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## Version Updates

Maritime RobotX Challenge 2022

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Version	Changes	Date
v1.0	First release of Maritime RobotX Challenge 2022 Team Handbook, based on “Rules & Requirements” and “Task Descriptions & Specifications” documents from 15 June 2021.	07 December 2021
v2.0	<ul style="list-style-type: none"> <li>1.4 New Point of Contacts section</li> <li>2.4.2 Updated Mandatory Activities: UAV</li> <li>2.5 Updated Task Descriptions</li> <li>2.5.4 Updated description of marine creatures to coated in paints, rather than painted images</li> <li>2.5.8 Updated colored disk, no sticker adhesives</li> <li>2.6, 2.7, 2.8 Added sections for Qualifying, Semi-Finals and Finals Rounds</li> <li>5.2.2 Detailed the On-Site Requirements deliverable</li> <li>5.3 Added dates in timeline</li> <li>5.4.2 Added Travel and Lodging section</li> <li>5.4.4 Added Venue Requirements section and Power section</li> </ul>	28 February 2022
v3.0	<ul style="list-style-type: none"> <li>2.1.1 Added Technical Design Paper guidelines/template</li> <li>2.2.2 Dates updated</li> <li>2.2.2 Time updated to 30-minute presentations</li> <li>2.4.2 Details on UAV Pilot Test linked</li> <li>2.5.4 Added visual display specifications and example</li> <li>2.5.5 Added visual display specifications and example</li> <li>3.1 Added scoring breakdown</li> <li>5.4.3 Added link to access shipping guidelines</li> </ul>	26 October 2022

Table 1. Document Version Log

# SECTION 1: RobotX Overview

Maritime RobotX Challenge 2022

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## 1.1 Dates & Venue

The 2022 Maritime RobotX Challenge (RobotX 2022) will be conducted 11-17 November 2022 at the Sydney International Regatta Centre Island, near Penrith in New South Wales, Australia. Multiple courses will be used for the competition (Figure 1).

### Health and Safety

Due to the evolving COVID-19 pandemic, international teams are encouraged to remain up-to-date on the travel and tourism guidance, for entering Australia, provided by the Australian Government.

Domestic teams are encouraged to remain up-to-date with the NSW Government COVID-19 regulations. For more information, see [Section 5: How to Compete](#).

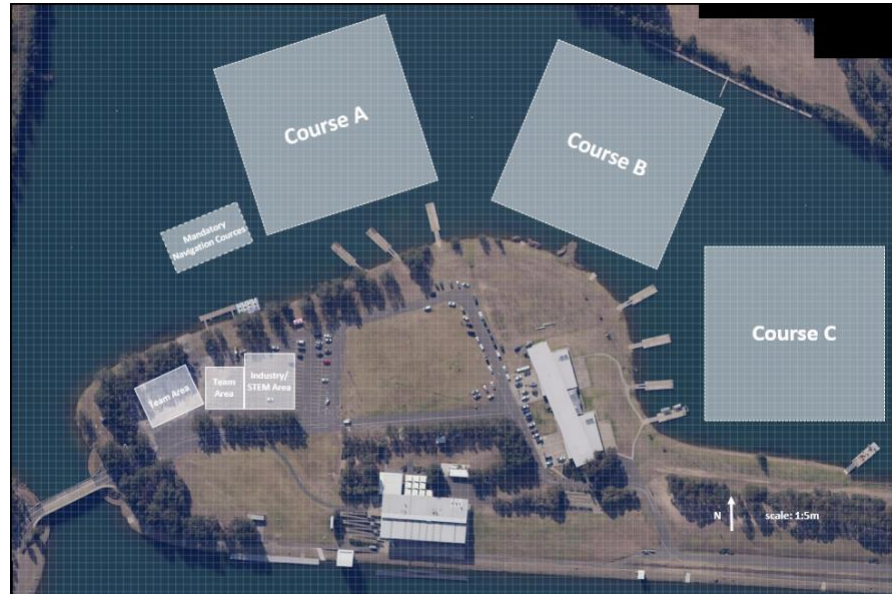


Figure 1: Preliminary Course Layout

## 1.2 Competition Structure

RobotX 2022 includes:

- **Design Documentation:** Teams present team's work and system design in a portfolio of design documentation prior to and on-site at competition.
- **Autonomy Challenge:** Teams demonstrate safety and performance.
  - **Qualifying Round:** Teams assemble and test their AMS, participate in initial safety inspections, practice, and attempt to qualify for Semi-Finals on the Qualifying and Practice Courses.
  - **Semi-Finals Round:** Qualified Semi-Finals teams complete runs on the Semi-Finals Courses, to attempt to qualify for Finals.
    - The Semi-Finals Course will become available after at least one team has qualified for Semi-Finals.
  - **Finals Round:** Qualified Finals teams complete runs on the Finals Course.

## 1.3 Eligibility

Teams can be from anywhere in the world and must use a WAM-V to compete.

### 1.3.1 Eligibility Details & Team Composition

- Teams must include a combination of students, faculty, industry partners, and/or government partners.
- The majority of the team members must be undergrad through post-grad students. Teams may also include high school students. Interdisciplinary teams are encouraged.
- All teams must include a member from the workforce.
  - Workforce team members may provide any combination of technical, financial, facility support; or other resources.
  - Former students and team members who have graduated and are employed within the workforce are encouraged to continue as team members and would fulfill the workforce member requirement.

## 1.4 Point of Contacts

**RobotX Questions:**  
[autonomy@robonation.org](mailto:autonomy@robonation.org)

**Registration Questions:**  
[support@robonation.org](mailto:support@robonation.org)

**Technical Questions:**  
[robotx.org/forum](https://robotx.org/forum)

**On-Site Logistics/Safety:**  
[events@robonation.org](mailto:events@robonation.org)  
850.642.0536

## SECTION 2: Competition

*Maritime RobotX Challenge 2022**www.robotx.org*

This section includes general information for the 2022 Maritime RobotX Challenge (RobotX 2022) including competition schedule, Design Documentation, and Autonomy Challenge.

### 2.1 Competition Schedule

A detailed competition schedule can be found on the [RobotX website](#).

Date	Event	Location
September-November	Design Documentation (prior to on-site competition)	Online
11 November	Team Orientation Vehicle Assembly Licensed Pilot Flight Tests	Sydney International Regatta Centre
12 November	Qualifying and Practice Course Open	
13 - 15 November	Qualifying and Practice Course Open Semi-Finals Course Open (after at least one team has qualified) Design Presentations System Assessment	
16 November	Qualifying and Practice Course Open Semi-Finals Course Open Semi-Finals Round Completed	
17 November	Finals Round Awards	

Table 2. RobotX 2022 Schedule

#### 2.1.1 Daily Events

Each day starts and ends with a mandatory meeting conducted by the Technical Directors. Team Leads are required to attend. All participants are strongly encouraged to attend.

- **Morning Meetings:** Technical Directors present the Plan-of-the-Day. Teams have an opportunity to provide feedback and ask questions.
- **Evening Meetings:** Technical Directors debrief the day's events, describe any course changes for the following day, and teams are encouraged to provide feedback.

### 2.2 Design Documentation

Prior to the on-site competition, teams provide a portfolio of design documentation. During the competition, teams give an oral presentation; and their AMS will be assessed by judges, who are subject matter experts (SME).

#### 2.2.1 Delivered Prior to On-Site Competition

The following design documentation is delivered, digitally, prior to the on-site competition. Submission instructions can be found in [Section 5.2 Pre-Competition Requirements](#).

#### Team Website

Teams are required to produce and submit a website, in English, that documents their team, system design, and competition approach, addressing the following areas:

1) Website Content: Layout and detailed contents of the website are left for the teams to develop; the website must include:

- Team name and contact information;
- Team photo, a list of team members and their contact information;
- System diagrams;
- Instructional/Informative videos;
- Procedures (text, images);
- Design decision documentation (text, images, videos);
- Blogs for historical records of build progress; and
- List of sponsors with logos.

2) Website Quality: Websites are often the first impression of a project. Potential supporters such as investors, employers, or advisors must find the website visually appealing and easy to navigate.

Development of the website should include careful consideration of user experience, including:

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

### Technical Design Paper

Teams are required to submit a technical design paper in English that describes the design of their USV and UAV autonomy systems, propulsion system, and control systems, as well as strategies for their approach to the tasks. This paper must include the rationale for the team's design choices. An editable template is available on the RobotX website: [robotx.org/2022](http://robotx.org/2022).

### Team Introduction Video

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

Format Requirements:

1. Teams must abide by all applicable COVID-19 requirements, appropriate to local protocols (i.e. wearing face masks, social distancing, etc.)
2. Video must be conducted in English or include English subtitles.
3. Video must be no more than three (3) minutes in length.
4. Video may include graphics, vehicle performance and/or simulation.
5. Videos must be hosted by team:
  - OPTION 1: Hosted on the team's YouTube or Vimeo account.
    - Must follow all [YouTube Rules & Policies](#) or [Vimeo Rules & Policies](#), including appropriate music licensing and copyright management.
  - OPTION 2: Host/embed on Team Website.



## 2.2.2 Delivered During On-Site Competition

### Design Presentation

Teams give a design presentation to a panel of SME judges. Each team must present what they plan to do on the course, and how that plan impacted their design and selections. This oral presentation must be conducted in English and may include visual aids. Teams must provide their own computer to connect to presentation screens. This presentation includes:

- Team Introduction Video (3 minutes)
- Presentation (15 minutes)
- Judge Question & Answer (5 minutes)
- Team & Judges Dialogue (7 minutes)

Teams are assigned a 30-minute presentation time on 12, 13, or 14 November.

### System Assessment

Judges inspect the team's AMS and assess 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 Assessment schedule will be provided at the competition site.

Teams are assigned a 30-minute assessment time on 15 or 16 November.

## 2.3 Autonomy Challenge

These challenges showcase AMS performance through autonomous completion of a range of tasks designed to represent research and real-world applications.

The task elements on the Autonomy Challenge differ from the equipment used in previous RobotX, RoboBoat, and RoboSub competitions. Under each task description is a table that includes the specifications that will be used for RobotX 2022.

### 2.3.1 Mandatory Activities

Prior to entering any of the Autonomy Challenge courses, teams are required to demonstrate their ability to safely operate their AMS. See [Section 2.4 Mandatory Activities](#) for more information.

### 2.3.2 Qualifying Round

At the start of competition, Qualifying and Practice Courses are available for teams to practice, demonstrate proficiency, and qualify for the Semi-Finals Round. Multiple teams may be on a Qualifying and Practice Course at the same time; but only one team can attempt to qualify on a task at any one time. Teams may schedule times to practice or qualify on individual tasks on these courses, with the Technical Director. The proficiency requirements for qualifying on each task can be found in [Section 2.6 Qualifying Round](#).

### 2.3.3 Semi-Finals Round

Teams that qualify for the Semi-Finals will have access to the Semi-Finals Courses. Teams operating on the Semi-Finals Courses may earn points towards entry into the Finals Round. Only one team may be on a Semi-Finals Course at a time. During the Semi-Finals Round, teams may attempt tasks in any order and must operate autonomously for the entire run. The proficiency requirements for Semi-Final runs can be found in [Section 2.7 Semi-Finals Round](#).

### 2.3.4 Finals Round

During the Finals Round, successful completion of the full Finals Course requires the AMS to demonstrate the ability to collect and use information from individual tasks to complete other tasks. Only one team may be on a Finals Course at a time. The AMS must operate autonomously for the entire run. The proficiency requirements for Final runs can be found in [Section 2.8 Finals Round](#).

## 2.4 Mandatory Activities

The mandatory USV Demonstration and UAV Demonstration must be successfully completed prior to entering an Autonomy Challenge course or attempting a task.

### 2.4.1 USV Demonstration

#### Static Safety Inspection

Prior to deploying in the water, the USV must meet all safety requirements. At a minimum, the following safety requirements will be checked:

- Buoyancy Pods;
- Emergency Stop System (location of switches, on-board and remote functionality);
- Tow points and tow line are clearly marked (forward and aft);
- Lift points are clearly marked;
- Safety requirements for propellers, including propeller guard; and
- All systems are properly secured.

More details on system requirements are available in [Section 4.3.1 USV Requirements](#).

#### Dynamic Navigation Demonstration

This demonstration is a mandatory requirement to enter the Autonomy Challenge course for Qualifying and Practice, Semi-Finals and Finals Rounds. After the USV Static Safety Inspection, teams must demonstrate that the USV can autonomously maintain positive control and effectively detect and navigate the channel markers; the USV must successfully navigate between two pairs of red and green buoys; as shown in Figure 2. The Dynamic Navigation Demonstration may be completed with or without the UAV on-board the USV.

Teams may be required to repeat this demonstration each time the USV is re-deployed in the water.

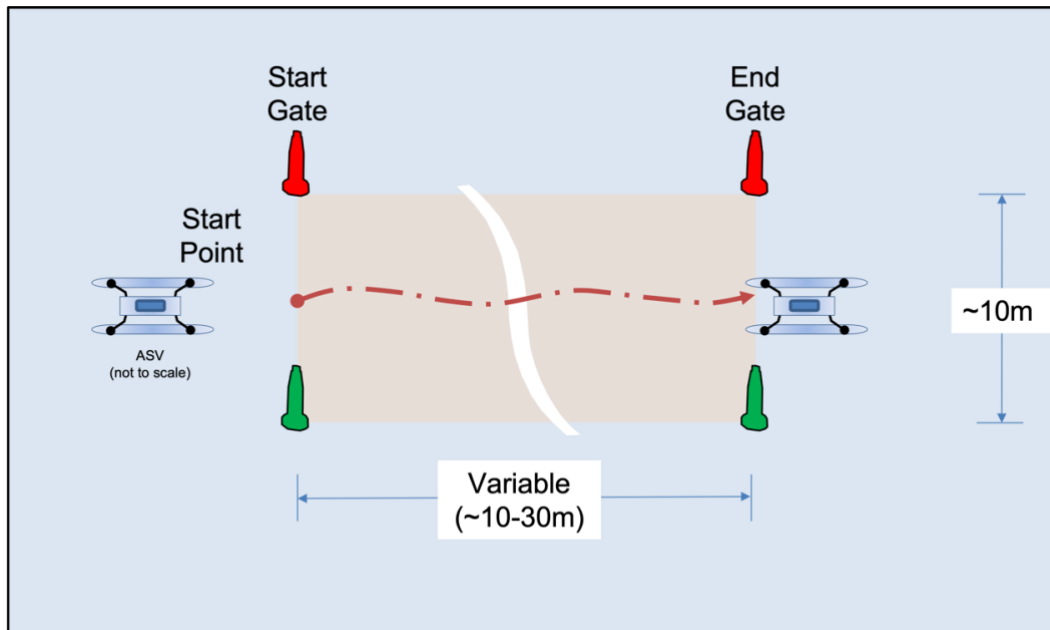


Figure 2. Dynamic Navigation Demonstration

Task elements for Dynamic Navigation Demonstration are detailed in Table 3.

Task Element	Description	Color	Ht. Above Waterline	Base Diam.
Start Gate Port Buoy	650mm Dia. Marker Buoy	Stock Red	850mm	650mm
Start Gate Starboard Buoy	650mm Dia. Marker Buoy	Stock Green	850mm	650mm
End Gate Port Buoy	650mm Dia. Marker Buoy	Stock Red	850mm	650mm
End Gate Starboard Buoy	650mm Dia. Marker Buoy	Stock Green	850mm	650mm
Buoys are supplied from Marine Buoys Australia: <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>				

Table 3. Task Elements for Dynamic Navigation Demonstration

## 2.4.2 UAV Demonstration

### UAV and Pilot Certification

Teams must meet all requirements mandated by the Model Aeronautical Association of Australia (MAAA) with respect to pilot licensing for this class of UAV being operated and including pilot certification; outlined in [Section 5.2 Pre-Competition Requirements](#).

### Static Safety Inspection

Prior to being cleared for flight, the UAV must pass a static safety inspection. At a minimum, the following safety requirements will be checked:

- Meets the limitations for size and weight;
- Safety issues related to propellers and hazards; and
- All sub-systems are properly secured.

More details on system requirements are available in [Section 4.3.2 UAV Requirements](#).

### Pilot Flight Proficiency Test

On the first day of competition, teams are required to have each licensed pilot pass a flight test as supervised by MAAA. The objective of the Pilot Flight Proficiency Test is to demonstrate the pilot's ability to take control of the UAV if required and land it safely as and if required. More details and instructions can be found on the [RobotX website](#).

### Dynamic Safety Demonstration

Prior to being cleared for entry on the Autonomy Challenge course, the UAV must conduct a successful demonstration. More details and instructions can be found on the [RobotX website](#).

*Pre-flight check includes:*

1. Physical inspection of airframe as per your standard check list. It should as a minimum cover:
  - Propellers
  - Motor mounts
  - General airframe and wiring integrity
  - Battery security
  - Battery capacity checks
  - Range test(s)
  - Integration tests with autonomous systems
2. Autonomous flight control disconnected to enable manual flight control mode.

*Post-flight check includes:*

1. Physical inspection of airframe as per your standard check list. It should as a minimum cover:
  - Propellers
  - Motor mounts
  - Battery security
  - Battery capacity checks



## 2.5 Task Descriptions

This section provides details of the RobotX 2022 Autonomy Challenge tasks and the proficiency requirements for each round of competition. Teams are encouraged to develop a strategy to approach these tasks that best suits their AMS.

### 2.5.1 Task 1 – Situational Awareness & Reporting

This task provides a situational awareness standard between the AMS and Technical Directors. The AMS is required to transmit a heartbeat message to the Technical Director (TD) Network (see [Appendix C](#)) to ensure that all required messages and reporting can be achieved.

While attempting Autonomy Challenge tasks, the AMS transmits specific messages and reports as outlined in [Appendix C: Communications Protocol](#).

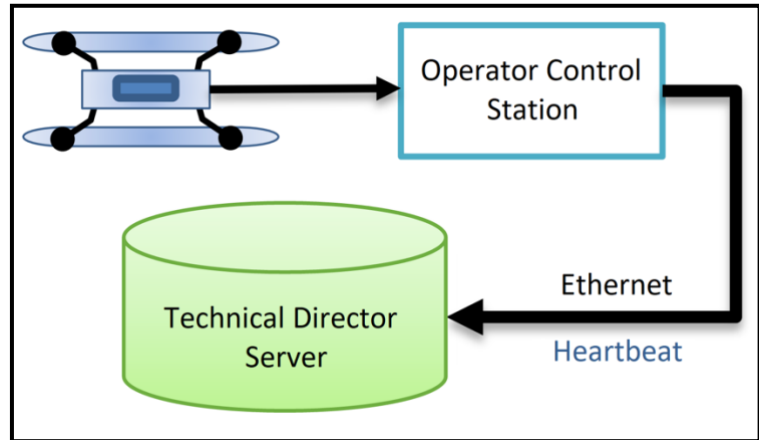


Figure 3: AMS Heartbeat

### Task Description

At each course operations tent, teams are provided with a wired RJ45 connection to connect to the TD Network. Information from the team's Operator Control Station (OCS) is transmitted to the TD network, using the RJ45 connection. Teams are expected to provide their own wireless link for information exchange between the AMS and the course OCS.

### 2.5.2 Task 2 – Entrance and Exit Gates

This task requires the AMS to enter and exit the course through the gates. The three gates are marked by four colored buoys (see Figure 4); in between each set of buoys is an underwater beacon. The AMS should detect the beacon and enter the course through those gates before proceeding to other tasks. The complexity of this task is raised between each of the rounds, incorporating other task's elements.

#### Task Description

There are four buoys designating the three gates:

- Gate 1 is bounded by a red buoy and a white buoy;
- Gate 2 is bounded by two white buoys; and
- Gate 3 is bounded by a white buoy and a green buoy (see Figure 4).

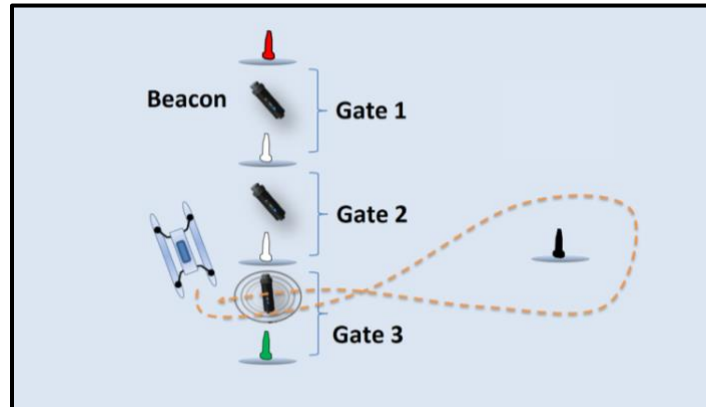


Figure 4: Example Entrance and Exit Gate Task

In between each of the gates is a submerged beacon (specifications available in [Appendix B: Beacon Specifications](#)). The red, white and green buoys are approximately 10m apart, with the black buoy being approximately 20m from the gates. The beacon frequencies for each course are separated by at least 2kHz and staggered in time and frequency. Only one beacon on each course will be activated at any time – when the task is being attempted by an AMS; frequencies for each instance of this task will be posted daily.

#### Task Elements

Task Element	Description	Color	Ht. Above Waterline	Base Diam.
Port Buoy	0.65m Dia. Marker Buoy	Stock Red	0.85m	0.65m
Gate Buoys (Quantity: 2)	0.65m Dia. Marker Buoy	Stock White	0.85m	0.65m
Starboard Buoy	0.65m Dia. Marker Buoy	Stock Green	0.85m	0.65m
Buoy to Circle	0.65m Dia. Marker Buoy	Black	0.85m	0.65m
Buoys are supplied from Marine Buoys Australia: <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>				

Table 4: Task Elements for Entrance and Exit Gates

### 2.5.3 Task 3 – Follow the Path

This task consists of a set of white buoys, followed by six pairs of red and green buoys, followed by another set of white buoys. The AMS detects the pathway and enters through one set of white buoys, from either end. The AMS navigates between the red and green buoys and exits between the other set of white buoys (see Figure 5), without making contact with any obstacles (round black buoys). These obstacles are placed at random within the task area. Teams may use a UAV to aid in accomplishing this task.

Teams that wish to experience a virtual version similar to this task may visit <https://github.com/osrf/vrx>.

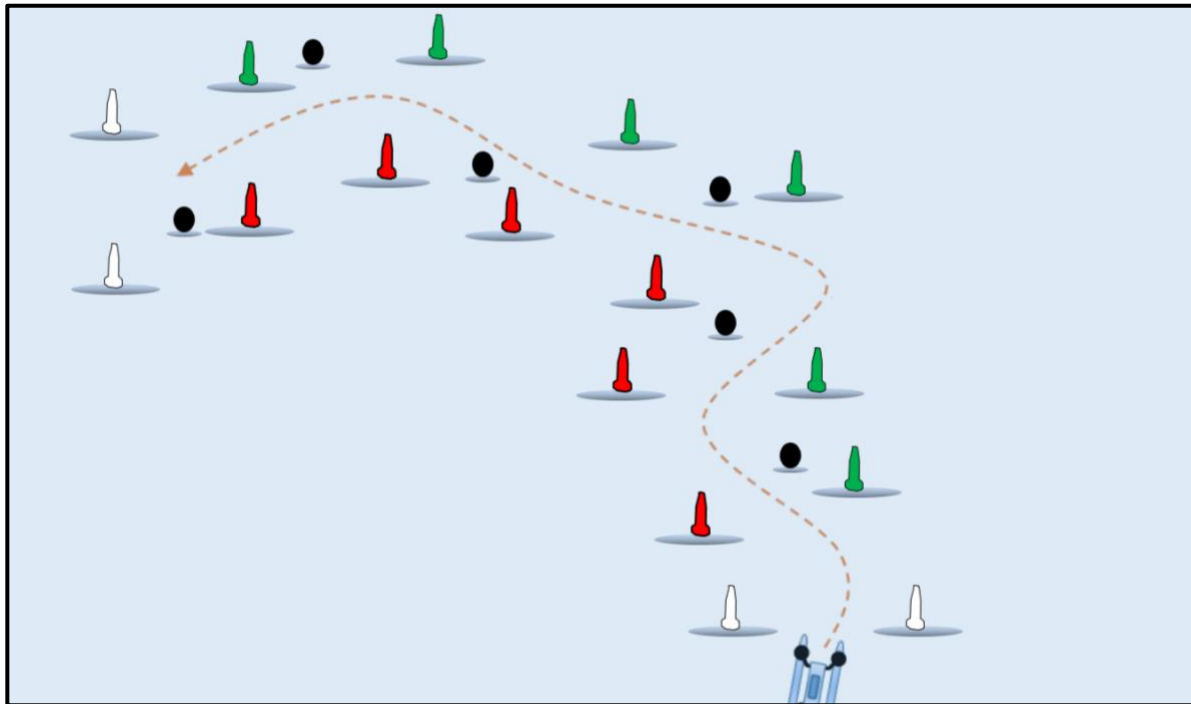


Figure 5: Example Follow the Path Task

#### Task Description

The white buoys designate the start and end of the pathway. The red and green pairs of buoys are located in between the pathway start and end. Black, round obstacle buoys are placed within the task boundary at random.

### Task Elements

Task Element	Description	Color	Ht. Above Waterline	Base Diam.
Field Boundary	0.47m Dia. Round Foam Filled Barrier Buoy	Stock Orange	0.47m	0.47m
Path Start/End (Quantity: 4)	0.65m Dia. Marker Buoy	Stock White	0.85m	0.65m
Path Buoy (Quantity: 6)	0.65m Dia. Marker Buoy	Stock Red	0.85m	0.65m
Path Buoy (Quantity: 6)	0.65m Dia. Marker Buoy	Stock Green	0.85m	0.65m
Obstacle	0.47m Dia. Round Buoy	Black	0.47m	0.47m
Field Boundary and Obstacle buoys are supplied from Boat Accessories Australia: <a href="http://www.boataccessoriesaustralia.com.au">www.boataccessoriesaustralia.com.au</a>				
Additional buoys are supplied from Marine Buoys Australia: <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>				

Table 5: Task Elements for Follow the Path

#### 2.5.4 Task 4 – Wildlife Encounter – React and Report

The Wildlife Encounter – React and Report task consists of three floating platforms, which represent three different Australian marine creatures: a platypus, turtle and crocodile (see Figure 6). The AMS identifies, reacts and maneuvers around the platforms. Each signature may be identified and classified using a Hyperspectral Imaging (HSI) camera. Teams may use their UAV to aid in accomplishing this task.

After the AMS detects and classifies the spectral signatures of each platform, the USV uses the information to (as an example):

- Circle the platypus in a clockwise direction;
- Circle the turtle in an anti-clockwise direction; and
- Circle the crocodile twice in any direction.

In addition, the AMS reports the location of each marine creature. Data and imagery collected during this task is submitted to the judges for review. The reporting format and details will be provided at a later date.

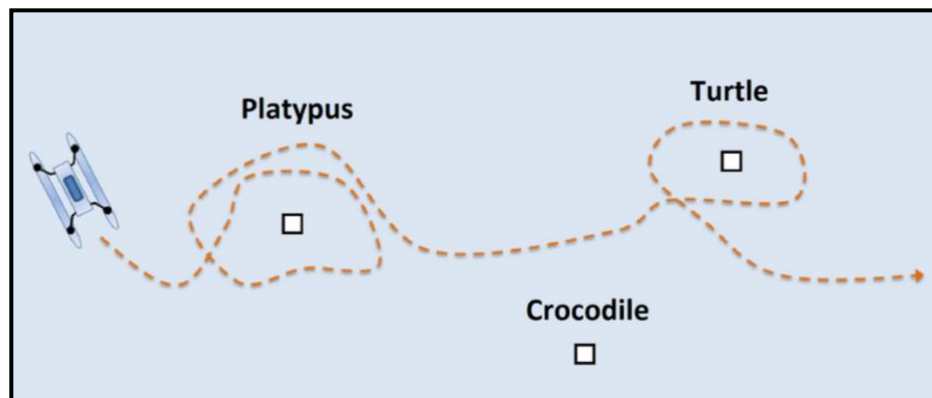


Figure 6: Example Wildlife Encounter – React and Report Task



### Task Description

Each of the three floating platforms, are made from a 1.5m x 1.5m plywood piece, painted with a unique spectral signature, each representing a different marine creature. Using the RoboNation Hyperspectral Imaging (HSI) camera the AMS should identify the 'marine creatures' by their unique spectral reflectance signature and maneuver through the task accordingly. Note: to an RGB camera, these spectral paints will likely be indistinguishable.

### Visual Display

Teams may provide a Scan the Code graphical display as detailed in Figure 7. The example Scan the Code in Figure 8 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 team's course operations area.

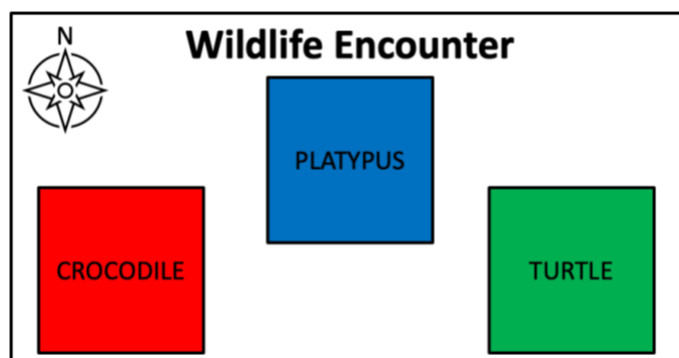
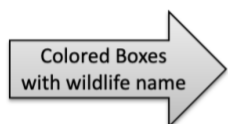


Figure 7: Wildlife Encounter Task Visual Display Example

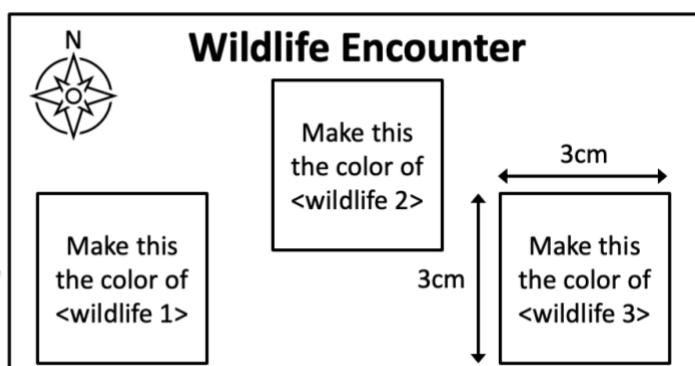


Figure 8: Wildlife Encounter Task Visual Display Specifications

### Task Elements

Task Element	Description	Color	Ht. Above Waterline	Base Dimensions
Floating Platforms (Marine Creature)	Horizontal plywood painted each with different spectral signature. The plywood sits on top of floating dock of similar dimensions.	"Grey"	~0.4m	1.5m x 1.5m
Field Boundary	0.47m Dia. Round Buoy	Stock Orange	0.47m	0.47m
Floating Dock	Floating platform that holds Marine Life Markers	N/A	N/A	1.5m x 1.5m
HSI Camera	A hyperspectral camera is provided at no cost, to registered teams, that wish to undertake this task. (Appendix E: Hyperspectral (HSI) Cameras)			
Field Boundary buoys are supplied from Boat Accessories Australia: www.boataccessoriesaustralia.com.au				

Table 6: Task Elements for Wildlife Encounter – React and Report

### 2.5.5 Task 5 – Scan the Code

This task consists of a light tower with three faces, atop a floating platform, which displays an RGB light sequence. The AMS observes the three-light sequence displayed, and reports the colors observed and the sequence of their occurrence. The AMS may use the light sequence to complete other tasks during the Semi-Finals and Finals Rounds.

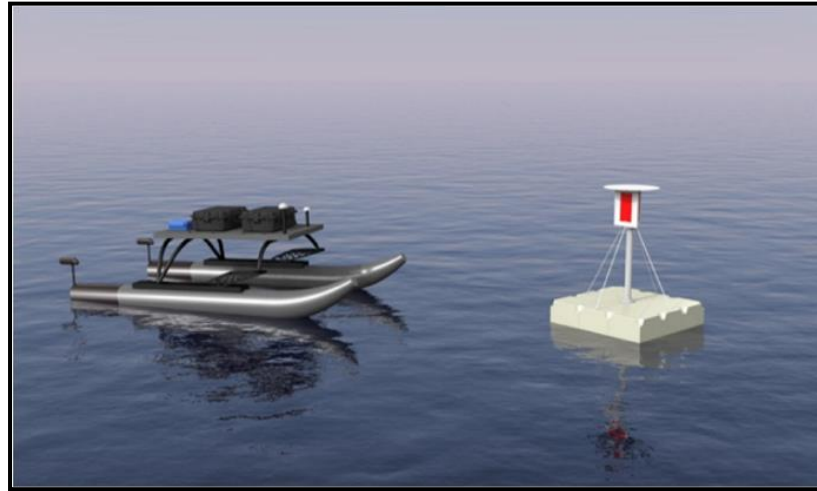


Figure 9: Example Scan the Code Task

*Note : Light Tower platform consists of 5x3 (15 total) blocks. On the northern face of the platform will be a solar panel pack raised at ~30 degrees and a batter pack behind.*



Figure 10: Example light pattern and timing sequence

#### Task Description

The light tower is no more than 3m above the surface of the water, and within a 40m x 40m task area. The light appears black when off/inactive. When activated the light displays colors one at a time, and randomly generates a three-color sequence (e.g. red-green-blue). Each color appears for 1 second, followed by the second and third. After this the light remains off (black) for 2 seconds (see Figure 10). The same pattern is repeated continuously. A color may be repeated in the three-color pattern, but the same color will not appear twice in a row (see Figure 11). The sequence may change between each run.

1st Color	2nd Color	3rd Color
RED	GREEN	BLUE
RED	BLUE	GREEN
BLUE	RED	GREEN
BLUE	GREEN	RED
GREEN	BLUE	RED
GREEN	RED	BLUE
RED	GREEN	RED
RED	BLUE	RED
GREEN	RED	GREEN
GREEN	BLUE	GREEN
BLUE	GREEN	BLUE
BLUE	RED	BLUE

Figure 11: Example light pattern color combinations

### Visual Display

Teams may provide a Scan the Code graphical display as detailed in Figure 12: Scan the Code Visual Display Example. The example Scan the Code 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 team's course operations area.

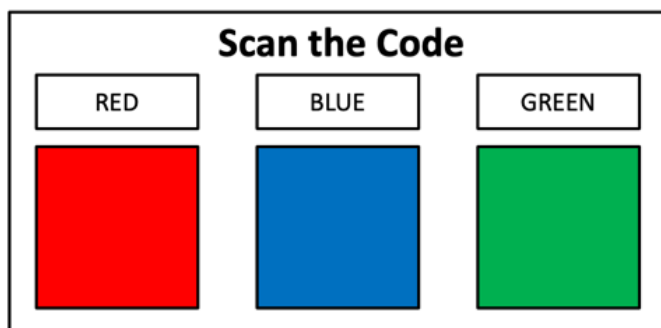


Figure 12: Scan the Code Visual Display Example

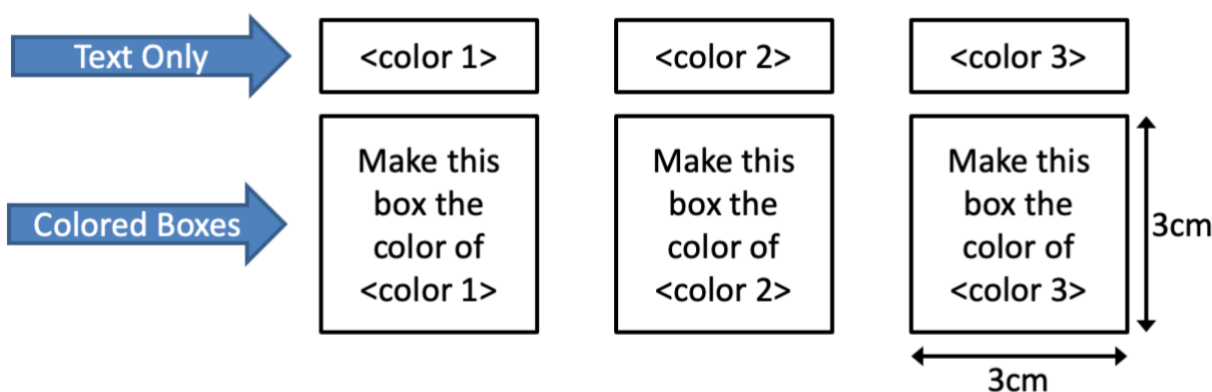


Figure 13: Scan the Code Visual Display Specifications

### Task Elements

Task elements for the Scan the Code task are detailed in Table 7 and in [Appendix A: Light Tower Specifications](#).

Task Element	Description	Ht. Above Waterline	Base Dimensions
Floating Dock	Floating platform that holds tower structure. <i>Note: the North facing side of the tower will have a ~0.6m x 2m solar panel array and battery box to power the light tower.</i>	~0.3m	1.5m x 1.5m
Light Tower	Specifications are detailed in <a href="#">Appendix A: Light Tower Specifications</a>	1-3m	N/A
Dock units are supplied from DOCKPRO: <a href="http://dockpro.com.au">dockpro.com.au</a>			

Table 7: Task Elements for Scan the Code Task

### 2.5.6 Task 6 – Detect and Dock

This task consists of a floating platform with three docking bays as shown in Figure 14. Each bay has a different colored panel (red, green, or blue). The AMS detects the designated color and docks within the corresponding bay.

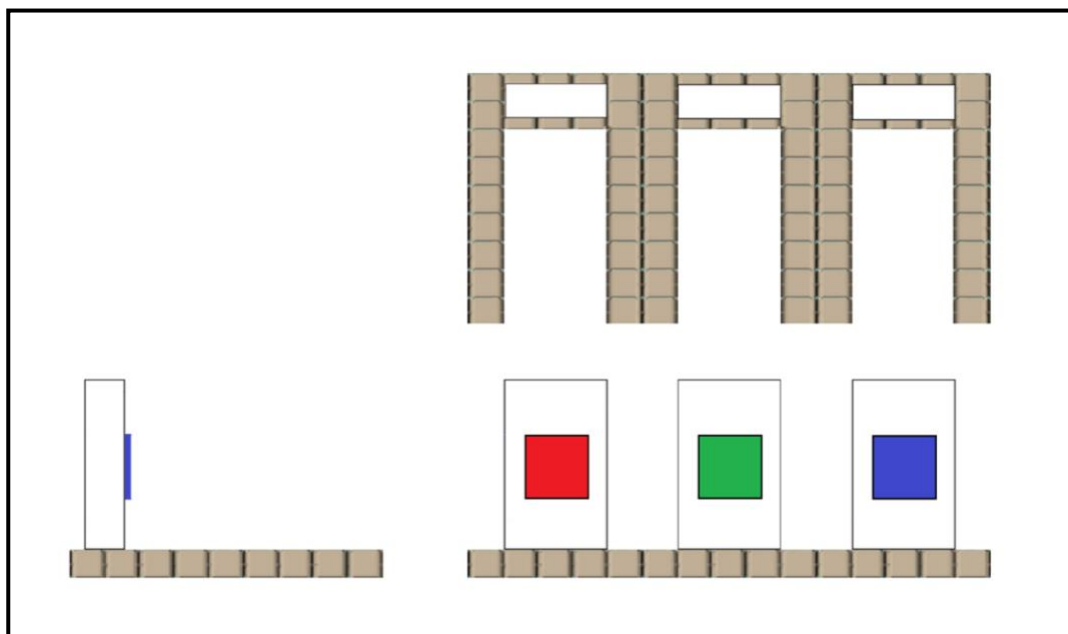


Figure 14: Example Detect and Dock Bays

#### Task Description

For this task, three identical interconnected docking bays arranged as shown in Figure 14 float at the water surface. The color panels are a 1m square vinyl panel with a 0.6m color square in the center of a white background; and elevated approximately 0.3m above the waterline.

#### Task Elements

Task Element	Description	Ht. Above Waterline	Base Dimensions
Floating Dock	Floating platform that holds panels	~0.3m	Overall width: 20m x 8m Tines: 2m x 6m Docking bay: 4m width
Flat-Panel Structure	Panels with color display	0.5m	1m x 1m Color display: 0.6m square (red, green, and blue)
Dock units are supplied from DOCKPRO: <a href="http://dockpro.com.au">dockpro.com.au</a>			

Table 8: Task Elements for Detect and Dock



### 2.5.7 Task 7 – Find and Fling

This task consists of a floating platform with three panels; each panel has a color square and two square holes (see Figure 15). The AMS finds a designated color and flings racquetballs into either of the two holes. Teams will be given four racquetballs, for their AMS to ‘fling’ through the holes in the panel.

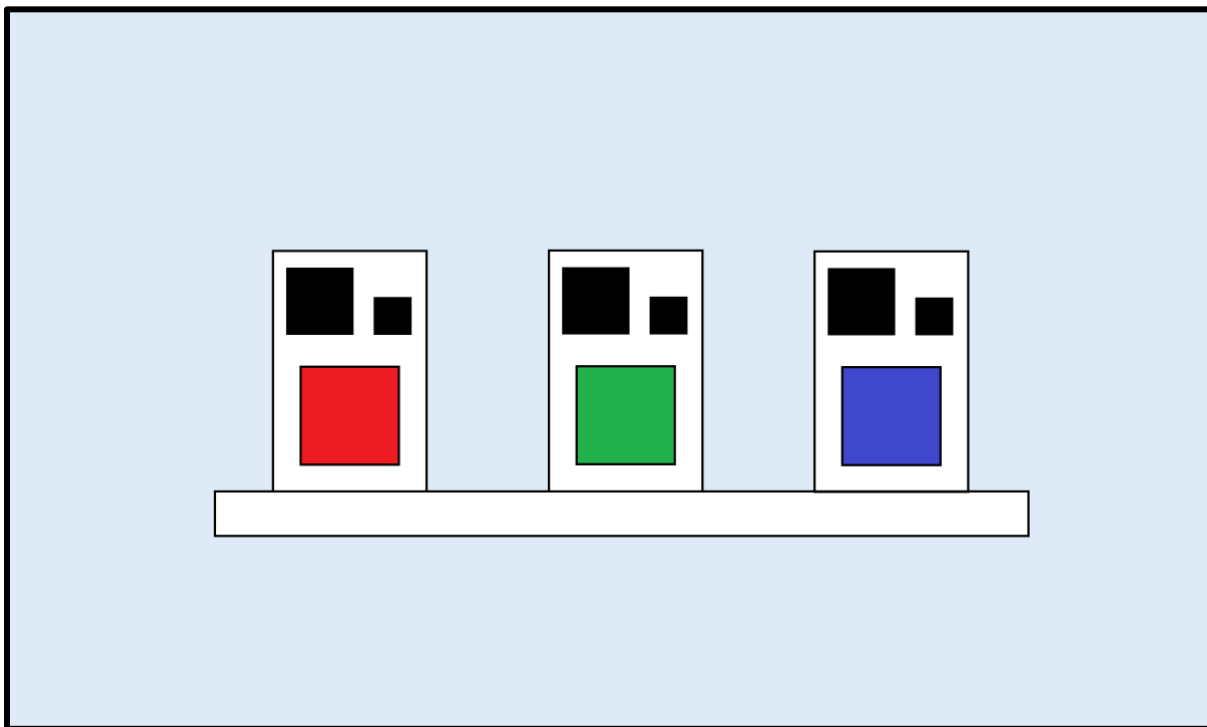


Figure 15. Find and Fling Task floating platform and panel structures

#### Task Description

For this task, three white panel structures are supported on a floating dock. Each panel has a color square affixed to it and two square openings (holes) cut out at the top of the panel. One of the holes is 0.5m on a side, and the other is 0.25m on a side. The holes are located next to one another above the color square. Each hole is outlined in black. The color square is 0.6m square and displays one of three colors: red, green, or blue. The color square is affixed about 0.5m above the waterline. The white, flat panel structures are spaced evenly across the floating platform as shown in Figure 15.

#### Task Elements

Task Element	Description	Base Dimensions
Floating Dock	Floating platform that holds panels	Overall width: 20m x 4m
Flat-Panel Structure	Panels with color display	1.5-3m x 2-3m Color display: 0.6m square (red, green, and blue)
Projectile	Penn Ultra-Blue Racquetball	N/A

Dock units are supplied from DOCKPRO: [dockpro.com.au](http://dockpro.com.au)

Table 9: Task Elements for Find and Fling

### 2.5.8 Task 8 – UAV Replenishment

This task is designed to be accomplished using a UAV. The UAV launches from the USV, locates a floating helipad and collects a small colored tin (see Figure 16). The UAV delivers the tin to the circular target area on another floating helipad, then returns to the USV.

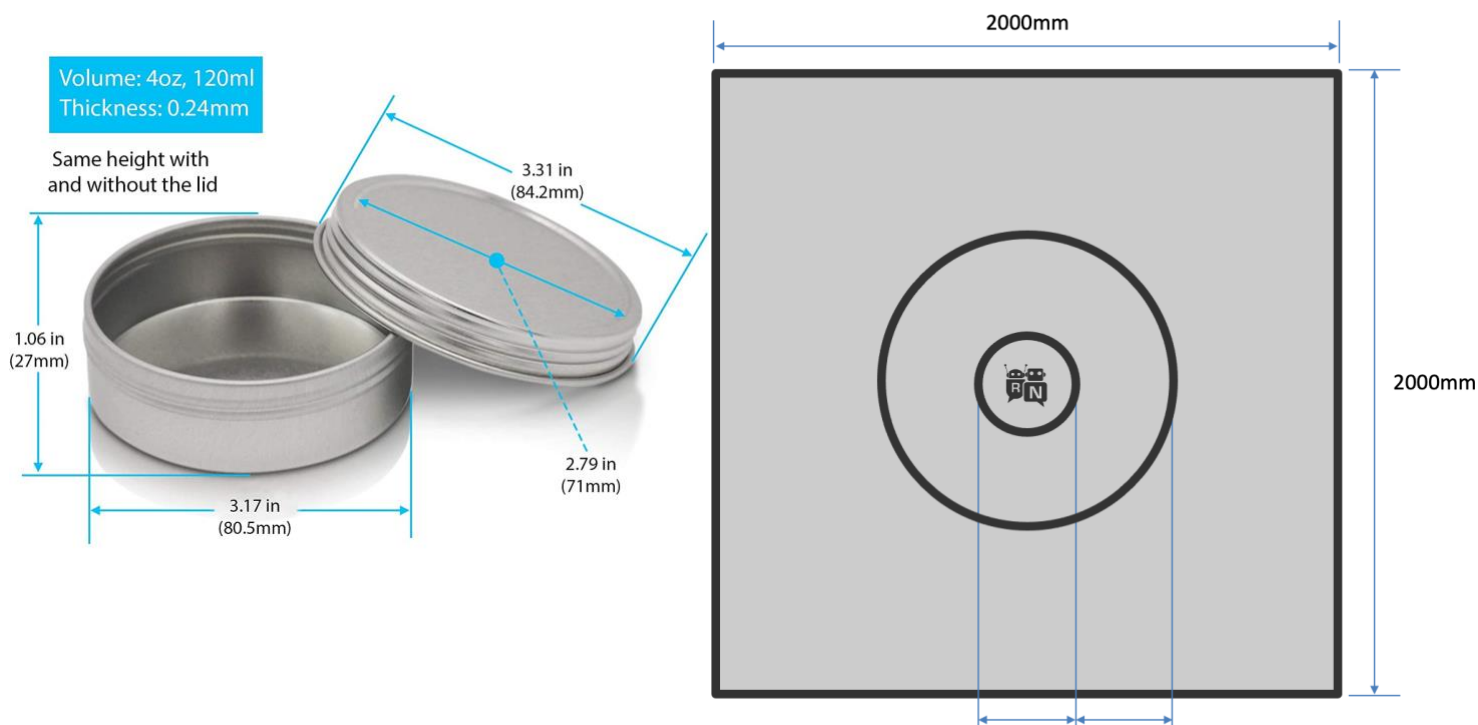


Figure 16: Colored Disk and Preliminary Helipad

#### Task Description

The two floating helipads are 2m x 2m and raised approximately 0.3m from the surface of the water and marked with concentric rings. The center ring is 0.24m in diameter, and the outer ring is 0.72m in diameter. The colored tin will be placed within the 0.24m ring.

The composition of the colored disks is described in Table 10. There may be multiple-colored discs on a helipad, (red, green, or blue). (Figure 16)

#### Task Elements

Task Element	Description	Base Dimensions
Floating Dock	Floating platform that holds helipad	Overall width: 2m x 2m
Helipad	See Figure 16. Helipad will be secured on a hard, flat, raised surface floating on the water.	2m x 2m
Colored Disks	SimbaLux Screw Top Round Steel Tin Cans 4 oz (120 ml). See Figure 16. Available for purchase: <a href="http://www.amazon.com">www.amazon.com</a>	N/A
Dock units are supplied from DOCKPRO: <a href="http://dockpro.com.au">dockpro.com.au</a>		

Table 10: Task Elements for UAV Replenishment

### 2.5.9 Task 9 – UAV Search and Report

This task can be attempted by any team once they have demonstrated that their UAV can autonomously launch and land safely ([Section 2.4 Mandatory Activities](#)). This UAV task is conducted on land and is designed to mimic that of a search and rescue.

For this task, the UAV launches from a designated start point, conducts a search of a field marked by four orange markers, detects and determines the location of two distinct objects in the field, and lands at the designated end point. Teams may implement any search pattern; however, the UAV must stay within the boundary of the task. Teams report the object and its geographic location.

#### Task Description

The start and end points for this task are two helipads. Each helipad is approximately 1.5m x 1.5m and is marked with concentric rings. The center ring is 0.24m in diameter, and the outer ring is 0.72m in diameter. The helipads are positioned at the long ends of a field approximately 10-30m long x 10m wide.

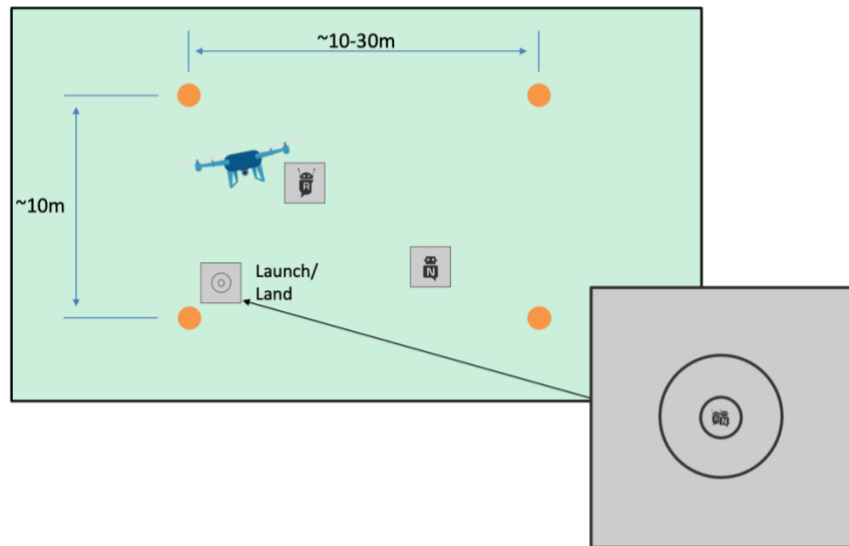


Figure 17. UAV Search and Report

There are two objects placed randomly within the field. The objects are approximately 1.5m x 1.5m and are marked with a RoboNation 'R' and an 'N' (80% grey color logos on 20% grey color background). The field is marked by 4 round orange markers affixed to the ground.

#### Task Elements

Task Element	Description	Color	Base Diam.
Field Boundary	Marker (Traffic Cone)	Stock Orange	
Objects	Flat white panel with 'R' or 'N' RoboNation symbol	White	1.5m x 1.5m
Helipad	See Figure 17. Helipad is secured on a hard, flat, raised surface.	N/A	2m x 2m

Table 11: Task Elements for UAV Search and Report

## 2.6 Qualifying Round

Three Qualifying and Practice Courses are available for teams to practice, demonstrate proficiency, and qualify for the Semi-Finals Round. These courses consist of eight (8) tasks, Tasks 1-8; Task 9 is conducted on land. Multiple teams may be on a Qualifying and Practice Course at the same time. Teams may schedule times to practice or qualify on individual tasks on these courses, with the Technical Director. Teams may attempt qualification on individual tasks in any order.

Once a team demonstrates proficiency on 5 of the 9 tasks, they qualify for the Semi-Finals Round. Once a team qualifies for the Semi-Finals Round they may continue to use the Qualifying and Practice Courses for practice on individual tasks. Teams who have not yet qualified for the next round, may continue to use the Qualifying and Practice Course to practice.

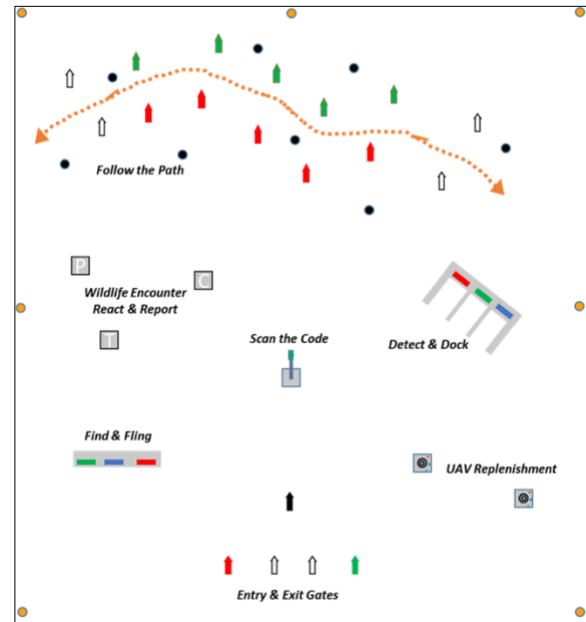


Figure 18: Preliminary Qualifying & Practice Course Layout

The minimum success criteria for qualifying on the individual Autonomy Challenges are detailed in [Section 3: Scoring](#).

## 2.7 Semi-Finals and Finals Rounds

Teams that qualify for the Semi-Finals will have access to the Semi-Finals Courses; these courses consist of eight (8) tasks, Tasks 1-8. Only one team may be on a Semi-Finals Course and a Finals Course at a time.

During Semi-Finals and Finals runs the AMS must:

- operate autonomously throughout the entire run;
- transmit a heartbeat message to begin the run ([as described in Appendix C](#));
- enter the course through one of the gates in [Entrance and Exit Gates](#) task;
- perceive and use the light sequence from [Scan the Code](#) task to inform execution of other tasks; and
- attempt the remaining Tasks 3-8 of their choice, in any order.

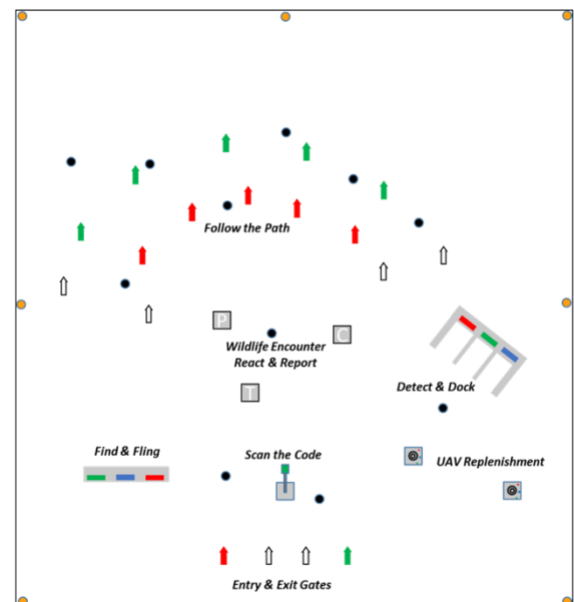


Figure 19: Preliminary Semi-Finals & Finals Course Layout

The scoring criteria for Semi-Finals and Finals are detailed in [Section 3: Scoring](#).



## SECTION 3: Scoring & Awards

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### 3.1 Scoring

This section provides a description of judging criteria and scoring for Design Documentation and the Autonomy Challenge.

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

All teams that meet the minimum Qualifying Round requirements will be eligible to compete in the Semi-Finals Round. Upon completion of the Semi-Finals Round, the judges will announce the top-scoring teams who will progress to the Finals Round. The judges have the discretion to select the number of teams advancing to the Finals Round.

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

#### 3.1.1 Design Documentation Scoring

Design Documentation must be submitted in accordance to the requirements outlined in [Section 2.2 Design Documentation](#) and the dates outlined in [Section 5.3 Timeline section](#).

The Design Documentation scoring breakdown is summarized in Table 12.

Table 12: Design Documentation Scoring Summary

Design Documentation	Maximum Points
Website	300
Technical Design Paper	200
Team Introduction Video	150
Design Presentation	200
System Assessment	150
<b>Total Possible Points</b>	<b>1000</b>

Detailed scoring rubrics can be downloaded on the [RobotX website](#).

#### Website (300 points max)

Teams are required to produce and submit a website, in English, that documents their team, system design, and competition approach. Teams are evaluated on overall visual design, text/graphics balance, organizational flow, utility of site, and technical merit. It is not necessary to add animation effects unless it aids in the overall presentation of the team message.

**Technical Design Paper (200 points max)**

Teams are required to submit a technical design paper in English that describes the design of their USV and UAV autonomy systems, propulsion system, and control systems, as well as strategies for their approach to the tasks. This paper must include the rationale for the team's design choices. The link to the template can be found below. Teams are evaluated on overall appearance & formatting, adherence to instructions & template, text / graphics balance, engineering design decisions, autonomy challenge strategy, system performance objectives, strategy to sensors selected, strategy to propulsion components, strategy to software development, and approach to innovation.

**Team Introduction Video (150 points max)**

Teams are required to submit a video introducing their team members and highlighting their team personality. This video is meant to be a creative showcase of what makes each team unique, such as, the mission of the team or the team culture. Teams are evaluated on video quality, information organization, clear and effective communication, and creativity.

**Design Presentation (200 points max)**

Teams are required to conduct a design presentation to a panel of SME judges. Each team must present what they plan to do on the course, and how that plan impacted their design and selections. This oral presentation must be conducted in English and may include visual aids. Teams are evaluated on design objectives, competition strategic approach, technical merit, quality of visual aids, and team professional and interpersonal behavior.

**System Assessment (150 points max)**

Teams are required to be present to answer technical questions posed by judges during a system assessment: judges inspect the team's AMS and assess technical design, craftsmanship, technical innovation, and visual impact of the design. Teams are evaluated on technical design, craftsmanship, technical innovation, and visual impact of design.

**3.1.2 Autonomy Challenge Scoring**

The Autonomy Challenge occurs in three rounds: Qualifying Round, Semi-Finals, and Finals. The scoring is structured to provide an overall balance of potential points based on the expected degree of difficulty for each task. For the Qualifying Round minimum performance criteria is specified and no points are awarded. For the Semi-Final and Final Rounds points are awarded, as outlined in this section.

All scoring decisions made by the judges are final. Teams may request clarification of any scoring decision through their Embedded Team Judge.

**Embedded Team Judge**

Each team is assigned an Embedded Team Judge. This judge accompanies the assigned team throughout the entire competition. This judge also coordinates with the other judges to evaluate Autonomy Challenge performance.

**Summary of Scoring Approach**

During the Qualifying Round, individual tasks are judged in a binary manner. There are no scores collected in this round. Teams may attempt tasks multiple times until they successfully qualify on the task. Judges keep record as a team's AMS successfully qualifies on tasks. Once a team demonstrates proficiency on 5 of the 9 tasks, they qualify for the Semi-Finals Round. Teams are encouraged to continue attempting qualification on additional tasks.

During the Semi-Finals Round, teams may make multiple attempts to complete tasks on the integrated course. Each attempt will be recorded and scored separately. The **best score** earned during Semi-Finals will be used to determine placement in the Finals Round. Teams are encouraged to make as many attempts as possible to better their system performance, as additional attempts will not erase previous scores. For the Semi-Finals Round a time period will be specified.

During the Finals Round, teams may attempt to complete the course as many times as they wish within their allotted time. Judges will record scores for each attempt, and the **best run** will be counted. Crossing of the ENTRY GATE threshold is considered the start of a new attempt. A run is considered complete when either time runs out, or the AMS passes through the EXIT GATE.

### **Qualifying Round Judging Criteria**

Minimum success criteria for qualifying on the individual Autonomy Challenges are detailed below. Teams may use remote control to position their AMS near the start of each task during the Qualifying Round only.

#### *Task 1 – Situational Awareness and Reporting*

Qualification on this task is **mandatory for advancement** to the Semi-finals Round. The AMS must transmit the heartbeat message as defined in [Appendix C](#). The TD team confirms to the judges the heartbeat message has been received (see [Situational Awareness and Reporting Task Description](#)). Additionally, teams are highly encouraged to transmit the reporting component for the other Autonomy Challenge tasks.

#### *Task 2 – Entrance and Exit Gates*

The AMS should pass through an entry gate, circle the black buoy and exit back through the same gate (see [Entrance and Exit Gates Task Description](#)).

#### *Task 3 – Follow the Path*

The AMS must navigate through the pathway, entering through one set of white buoys and exiting through the other pair of white buoys, passing between at least one set of red and green buoys. The AMS may choose to deploy a UAV to assist with this task (see [Follow the Path Task Description](#)).

#### *Task 4 – Wildlife Encounter – React and Report*

The AMS must detect and scan at least one spectral signature and circumnavigate the corresponding wildlife platform as described in the Wildlife Encounter – React and Report Task Description.

#### *Task 5 – Scan the Code*

The AMS must perceive the three-color light sequence and report correctly via the TD Network using the protocol outlined in Appendix C and on the Judge's Display (see [Scan the Code Task Description](#)).

#### *Task 6 – Detect and Dock*

The AMS must detect the designated color and dock within the corresponding bay. For this round, the correct color is determined by the Technical Director (see [Detect and Dock Task Description](#)) and will be announced daily.

**Task 7 – Find and Fling:** The AMS must identify the correct color and successfully ‘fling’ one (1) of the four (4) racquet balls into either of the holes in the panel. The color of the panel is determined by the Technical Director (see [Find and Fling Task Description](#)).

**Task 8 – UAV Replenishment**

The UAV must launch from the AMS, pick up the colored tin from the floating helipad, and deliver it to the other floating helipad. The color of the tin to be collected is determined by the Technical Director (see [UAV Replenishment Task Description](#)).

**Task 9 – UAV Search and Report**

The UAV must launch from the designated launch site, complete a search pattern within the task boundary, report the location of the objects, and land at the designated landing site (see [UAV Search and Report Task Description](#)).

**Semi-Finals and Finals Round Judging Criteria**

In the Semi-Finals and Finals Round the AMS is required to demonstrate autonomy and perception by completing tasks using information obtained from one or more prior tasks.

During Semi-Finals and Finals runs the AMS must:

- operate autonomously throughout the entire run;
- transmit a heartbeat message to begin the run (as described in [Appendix C](#));
- enter the course through one of the gates in [Entrance and Exit Gates task](#);
- perceive and use the light sequence from [Scan the Code task](#) to inform execution of other tasks; and
- attempt the remaining Tasks 3-8 of their choice, in any order.

The scoring breakdown is summarized in Table 13: Maximum Points for Semi-Finals and Finals Round. Note that Design Documentation points are included as part of the Semi-Finals and Finals total scores.

Task Name	Max Points
Situational Awareness	100
Entrance and Exit Gates	600
Follow the Path	1100
Wildlife Encounter and Report	2500
Scan the Code	600
Detect and Dock	700
Find and Fling	1400
UAV Replenishment	1500
UAV Launch/Recovery	2500
Design Documentation	1000
<b>MAX Possible Points</b>	<b>12,000</b>

Table 13: Maximum Points for Semi-Finals and Finals Round

### *UAV Launch / Recovery*

Teams are encouraged to use a UAV to assist in completing the Autonomy Challenge tasks. Points for the autonomous launch and recovery of a UAV will be awarded once during each run.

Points are awarded as follows:

- 1000 points for launching UAV from USV.
- 1500 points for landing UAV back on USV.
- OR 500 points for landing UAV in recovery zone.

**MAXIMUM Total Points = 2500 points**

### *Task 1 – Situational Awareness and Reporting*

The AMS must begin transmitting the heartbeat message when it starts a run. Additionally, teams are highly encouraged to transmit the reporting component for the other Autonomy Challenge tasks (see [Appendix C: Communications Protocol](#)).

Points are awarded as follows:

- 100 points for transmitting first heartbeat message.
- *Additional points are awarded for each heartbeat message sent for each task, outlined below.*

**MAXIMUM Total Points = 100 points**

### *Task 2 – Entrance and Exit Gates*

On the Semi-Finals course, the black buoy in this task will be replaced with the Scan the Code light tower. The AMS should detect the active beacon to enter the course through the correct entry gate, before proceeding to the other tasks. At the end of the Semi-Finals run, the AMS must exit the course through the same set of gates as it entered (see [Entrance and Exit Gates Task Description](#)).

**ENTRY Gate:** The AMS must detect the ENTRY gate with the active beacon and successfully pass through that gate to start their run on a Semi-Finals Course.

**EXIT Gate:** At the end of the Semi-Finals run, the AMS must successfully pass through the EXIT gate, the same gate as it used to enter the course, to exit the course.

Points are awarded as follows:

- 50 points for course entry through any ENTRY gate.
- + 100 points for the CORRECT ENTRY gate.
- + 50 points for clean course entry, no buoy strikes.
- 50 points for course exit through any EXIT gate.
- + 100 points for the CORRECT EXIT gate.
- + 50 points for clean course exit, no buoy strikes.
- 100 points for transmitting a heartbeat message reporting the ENTRY gate.
- 100 points for transmitting a heartbeat message reporting the EXIT gate.

**MAXIMUM Total Points = 600 points**

### *Task 3 – Follow the Path*

The AMS must navigate through the pathway, entering through one set of white buoys and exiting through the other pair of buoys. Teams must avoid all black obstacle buoys. The AMS may choose to deploy a UAV to assist with this task (see [Follow the Path Task Description](#)).

Points are awarded as follows:

- 100 points for entering pathway correctly.
- + 100 points for each pair of buoys successfully navigated, in sequence.
- 100 points for exiting the pathway correctly.
- + 200 points for successfully navigating the full path in a single run with no buoy strikes (without exiting the path and returning).
- 100 points for transmitting a heartbeat message reporting completed path.

**MAXIMUM Total Points = 1100 points**

### *Task 4 – Wildlife Encounter – React and Report*

The AMS must detect and scan each spectral signature, signaling the USV to circle one designated marine creature (see [Wildlife Encounter – React and Report Task Description](#)). The AMS must locate the CORRECT marine creature floating platform and circumnavigate it in the correct direction.

To successfully circle the floating platform, the AMS must transit around the marine creature until it has crossed its approach path, transiting at least 360 degrees. The floating platforms must be circumnavigated as follows:

- Circle the platypus in a clockwise direction.
- Circle the turtle in an anti-clockwise direction.
- Circle the crocodile twice in any direction.

The CORRECT marine creature is determined by the **first two colors** in the light sequence from [Scan the Code](#). The corresponding colors are as follows:

- Blue corresponds to the platypus platform.
- Green corresponds to the turtle platform.
- Red corresponds to the crocodile platform.

Points are awarded as follows:

- 100 points for circling marine creature platform in any direction.
- + 100 points for circling CORRECT marine creature platform in any direction.
- + 500 points for circling CORRECT marine creature platform in CORRECT direction.
- 100 points for transmitting a heartbeat message reporting number of detected creatures.
- 1000 points for correctly formatted creature map.

**MAXIMUM Total Points = 2500 points**

### *Task 5 – Scan the Code:*

In the Semi-Finals Round the Scan the Code light buoy will be located beyond the set of entry gates. The AMS must perceive the three-color light sequence and convert data to inform execution of other tasks (see [Scan the Code Task Description](#)). The AMS must demonstrate correct perception of the light pattern through behaviors in other tasks. Additional points are awarded for reporting the color pattern detected.



Points are awarded as follows:

- 100 points for transmitting a heartbeat message reporting light sequence.
- + 200 points for transmitting a heartbeat message reporting CORRECT light sequence.
- 100 points for displaying light sequence on team console for Judges' Display.
- + 200 points for displaying CORRECT light sequence on team console for Judges' Display.

**MAXIMUM Total Points = 600 points**

*Additional points awarded in Tasks 4, 6, 7, and 8 for correct perception of light pattern.*

#### *Task 6 – Detect and Dock*

The AMS must detect the designated color and dock within the corresponding bay (see [Detect and Dock Task Description](#)). The color of the panel is determined by the first color in the light sequence from Scan the Code.

A docking attempt is considered successful when the AMS fully enters a docking bay between two of the adjacent pontoons. A docking attempt in which the AMS straddles a pontoon will not be considered successful.

Points are awarded as follows:

- 100 points for successfully docking in ANY docking bay (only awarded once).
- + 500 points for successfully docking in CORRECT docking bay (only counts toward first dock).
- 100 points for transmitting a heartbeat message reporting detected color.

**MAXIMUM Total Points = 700 points**

#### *Task 7 – Find and Fling*

The AMS must identify the correct color and successfully 'fling' racquet balls in either of the holes in the panel (see [Find and Fling Task Description](#)). The color of the panel is determined by the second color in the light sequence from Scan the Code.

Points are awarded as follows:

- 100 points for launching racquetball (only awarded once).
- + 100 points for each racquetball delivered into the larger hole.
- + 100 points for each racquetball delivered in the CORRECT larger hole.
- + 150 points for each racquetball delivered into the smaller hole.
- + 150 points for each racquetball delivered into the CORRECT smaller hole.
- 100 points for transmitting a heartbeat message reporting detected color.

**MAXIMUM Total Points = 1400 points**

### *Task 8 – UAV Replenishment*

The UAV must launch from the AMS, pick up the colored tin from the floating helipad, and deliver it to the other floating helipad (see [UAV Replenishment Task Description](#)). The color of the tin to be collected is determined by the third color in the light sequence from Scan the Code.

Points are awarded as follows:

- 200 points for picking up any disc.
- + 500 points for picking up CORRECT disc.
- 200 points for delivering any disc.
- + 500 points for delivering CORRECT disc.
- 100 points for transmitting a heartbeat message reporting the status of the UAV.

**MAXIMUM Total Points = 1500 points**

### *Task 9 – UAV Search and Report*

This task is not included in the Semi-Finals or Finals Round.

## **3.2 Awards**

Awards are provided in two categories: Final Standings and Judges' Special Awards.

### **3.2.1 Final Standings**

Teams are awarded prize money reflective of their overall ranking after scores are calculated. The first-place team receives a trophy and a RoboNation champion banner.

### **3.2.2 Judges' Special Awards**

Throughout the competition, judges and staff are always on the lookout for exemplary behavior from teams to acknowledge with special awards.

## SECTION 4: Rules & Requirements

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### 4.1 Rules

1. Teams must use a WAM-V to compete. ([Section 4.3: Platform & System Requirements](#))
2. No combustion engines of any type may be used on the AMS.
3. Teams must include a combination of students, faculty, industry partners, and/or government partners. ([Section 1.3: Eligibility](#))
4. One student member of the team must be designated as the “team lead”. The team lead must be conversationally fluent in English. The team lead, and only the team lead, will speak for the team during the competition runs.
5. Team leads are required to attend daily team meetings conducted by the Technical Directors. ([Section 2.1: Schedule](#))
6. Teams must remain on site at the competition venue during the competition hours to be eligible for prizes.
7. Prior to entering the Autonomy Challenge courses, teams must demonstrate the ability to operate their USV and UAV safely. ([Section 2.4: Mandatory Activities](#))
8. At any point, the Technical Director Team may require a team to repeat the USV Demonstration and UAV Demonstration to re-deploy. ([Section 2.4: Mandatory Activities](#))
9. Course boundaries will be clearly identified. The AMS must stay within the course or task boundaries while attempting any tasks.
10. Teams may use a UAV to aid in the execution of any task; however, notification must be given to the Technical Director Team prior to the task being attempted.
11. All decisions of the judges are final.
12. RobotX organizers are not responsible for any damage to a team’s AMS, including all subsystems, as the consequences of participating in the competition.

### 4.2 Safety

The safe operation of all equipment is a priority for the RobotX staff. All considerations to maintain safety for operators, spectators, and the surrounding environment must be made. These guidelines are the minimum requirements for all teams and their systems during the competition.

1. All Radio Frequency (RF) equipment must be operated within the rules and regulations of the host country. This includes, but is not limited to, frequency, transmitting power, antenna height, etc. This is detailed on the Australian Communications and Media Authority (ACMA) website and summarized in [Appendix D: Radio Communications Restrictions](#).
2. AMS power systems must follow the safety rules and regulations of the host country as well as the team’s home country.
3. RobotX staff may suspend team, task and/or course operations at any time for safety considerations. The staff are not required to advise teams prior to the decision to terminate the run attempt or other operations. In all matters of safety, the decisions of the RobotX staff are final.

#### 4.2.1 Safety Inspections

Before operating in or over the water and land courses, all systems must pass a safety inspection. This includes, but is not limited to:

1. A Safety Inspector will complete a safety checklist, verifying successful operation of all safety features at each unmanned system launch of the USV and UAV.
2. Teams will demonstrate compliance with all the requirements, to include identifying all actuators, and moving parts and their associated protection mechanisms (shrouds, etc.).
3. Verification of both kill switches' operation (remote and physical) will be repeated each time a team enters the water.
4. Teams bringing a UAV will be required to have each licensed pilot pass a flight test as supervised by MAAA. (Section 2.4 Mandatory Activities)

#### 4.2.2 Battery Safety Requirements

Teams are required to understand and follow battery safety best practices on the battery chemistry selected by the team. Lithium-ion chemistry batteries may become damaged and create a hazard if misused/abused, representing the greatest risk to people, facilities, and the environment. The following safety rules and requirements must be followed:

1. Teams must provide battery specifications, Material Safety Data Sheets (MSDS), and proper disposal procedures, sourced from the battery manufacturer for all batteries. These will be collected in the Pre-Competition Requirements.
2. Teams must provide battery specifications for shipments that include batteries, in the Shipping Plan which is part of the On-Site Requirements in the Pre-Competition Requirements.
3. Teams must keep a hard copy of the battery safety documentation for all batteries in Team Village (on-site) at all times, for reference.
4. Li-Po (Lithium Polymer) battery packs need cell level safety and balancing circuits and must be labeled HAZMAT when/if shipped.
  - Each team must understand and follow their own country's regulations as well as those of the host nation. Australia's battery safety regulations: [batterysafetyguide.com.au](http://batterysafetyguide.com.au).
5. All batteries must 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.
  - a. Lithium batteries that become too warm during use or have become swollen or malformed must be removed from use and reported to RobotX staff.
  - b. Lithium batteries that do not hold a charge must be removed from use and reported to RobotX staff.
  - c. Any loss of battery (i.e. dropped into the lake) must be reported immediately to RobotX staff.
7. A team member must be present at all times to monitor charging batteries. Batteries must not be left to charge overnight.
8. At the competition site, if any of the above battery conditions are observed students must immediately notify RobotX staff and provide the battery specifications and MSDS information.
9. Failed or failing Lithium-ion batteries must be handled in accordance with manufacturer's safety and disposal guidelines. In the absence of specific guidelines, batteries must be placed in a LiPo safe bag, which must then be placed in a bucket, covered with sand, and placed in a designated safety zone.
10. Teams are only permitted to change or replace AMS batteries in designated areas.

### 4.2.3 Kill Switch (Emergency Stop) Requirements

The AMS must comply with the kill switch requirements detailed below. The USV must have two emergency stop systems, also known as ‘kill switches’ or ‘E-Stops’.

- On-Board: A hard-wired, on-board, emergency stop system.
- Off-Board: A wireless remote emergency stop, located off-board and on or near the operator control station.

Upon activation of either emergency stop switch, the system must instantaneously (less than 1 second) disconnect power from the vehicle’s thrusters. Emergency stop systems must 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 loses connection, the switch must instantaneously (less than 1 second) disconnect power from the vehicle’s thrusters. An example of how to implement this is shown in Figure 20. Systems should be designed so that power, to the thrusters, cannot be restored until the emergency switch is reset.

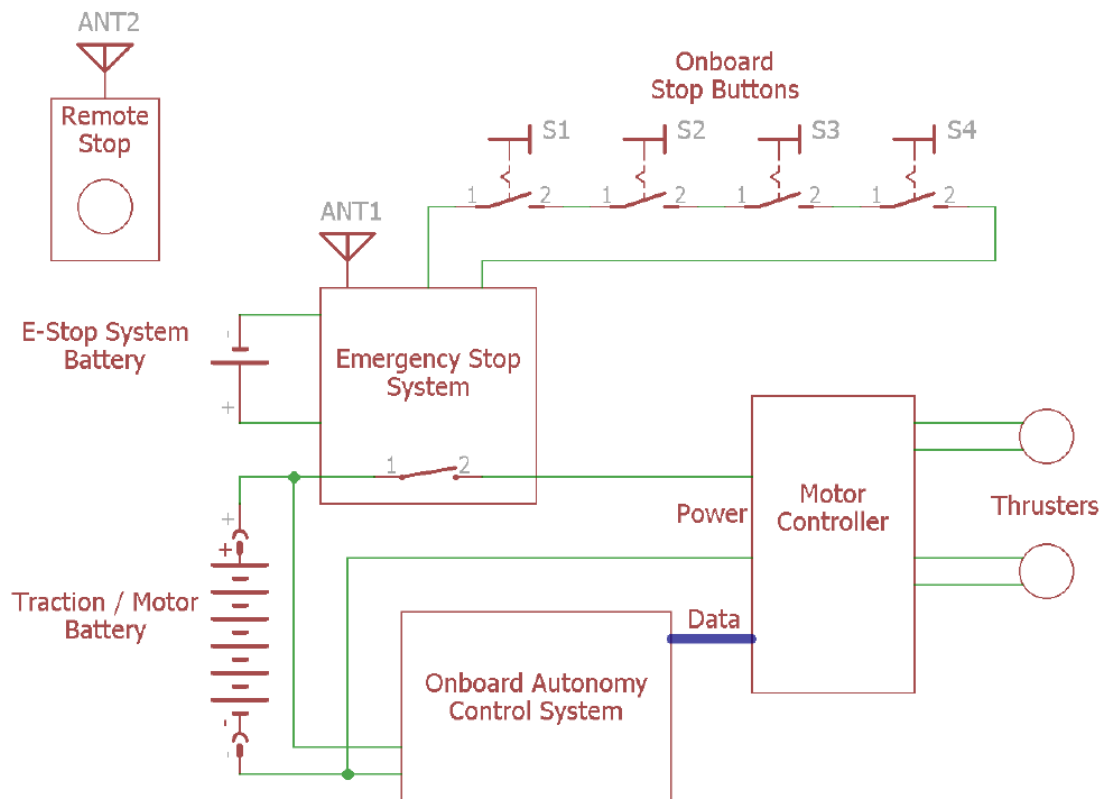


Figure 20: Example Emergency Stop Circuit

The Technical Director team will conduct a detailed engineering and safety inspection, including a team demonstration of the proper operation of all emergency systems. Teams must be prepared to discuss the design and implementation of their fail-safe systems in detail as, and when requested.

### Onboard Emergency Stop System (USV)

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

Teams must 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 21. This switch must be demonstrated to disable AMS thrusters within 1 second of activation in all AMS operating modes.



Figure 21: Examples of Kill Switch Placement

### Emergency Stop Button (USV)

A large, red button should be installed so that safety personnel, from the support craft can easily see and operate the button. The engage/disengage button should be red in color and have a 'press to activate and twist/pull to reset' feature. This button, momentary contact switch or not, should cut power to the thrusters immediately (within 1 second) on activation. 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 22 and can be found at [www.mcmaster.com](http://www.mcmaster.com).



Figure 22: Example Kill Switch

### Wireless Emergency Stop (USV)

All USVs must be equipped with a remote Wireless Emergency Stop controller. This controller must immediately (less than 1 second) disconnect power to the vehicle's thrusters when activated. This system must also meet the host country RF guidelines for frequency and transmit power.

### Emergency Manual Over-ride (UAV)

All UAVs must have an emergency manual over-ride which can be operated remotely off-board, operating on its unique frequency and link. Upon activation of the manual over-ride, the UAV must instantaneously stop all other tasks, be ascended to 25m above ground level, return under manual control of the pilot to a designated safe landing area.



#### 4.2.4 Visual Feedback System Requirements

Teams are required to implement a visual feedback system to clearly indicate the operational status of the USV to improve the safety of event support operations. This lighting system will serve as a visual status indicator to anyone in the vicinity of each team's USV. It is recommended the UAV also has a clearly visible indicator showing operational status. Resources and general guidelines outlined here may be used by teams to acquire, integrate, and test a system that meets the RobotX safety requirements.

##### Basic Requirements

The lighting system shall consist of a minimum of three lights: red, amber/yellow, and green/blue. Lights must be 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 14. The lights may be flashing or steady on/off according to the state of the system.

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

Table 14: Light Color and Correlating Modes

Several visual indicator examples are shown in Figure 23, including off-the-shelf and custom LED array approaches; however, design and selection of the final system is the team's decision.

##### Detailed Specification

- The minimum height of the lighting systems must be 12.5cm.
- The maximum height and diameter of the lighting system are at the team's discretion and may be dependent on the number of additional lights included.
- Teams must procure lighting systems that are visible in sunlight and can be observable from the shore and the on-water support craft (approximately 150m). Teams should use lighting systems that have clear enclosures rather than colored light sections with standard light bulbs.



Figure 23: Example Visual Indicators

### 4.3 Platform & System Requirements

#### 4.3.1 USV Requirements

- All teams are required to use the WAM-V-16 USV manufactured by Marine Advanced Robotics ([www.wam-v.com](http://www.wam-v.com)) as their primary competition USV.
- WAM-Vs must be equipped with buoyancy pods. Examples of previously used pod designs are presented on the RobotX website in the [RobotX Guide "WAM-V Propulsion Examples"](#) paper and student technical papers from previous events. Pods are also available directly from the WAM-V manufacturer.

3. Each USV must have at least two (2) orange tow points, one set forward and one set aft (Figure 24). The tow points are 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. 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.



Figure 24: Example tow points

4. The USV should be capable of operating in sunny, rain (light or heavy) and varying wind conditions. Although the competition location is normally sunny at this time of year, the competition will continue through these weather conditions. (Penrith, NSW Weather Observations in November 2021: [www.bom.gov.au/climate/](http://www.bom.gov.au/climate/) )
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. Propellers must be shrouded for safety.
7. Each team's WAM-V and trailers must fit under the competition tents (maximum allowable height: 3.028m). Additional masts are acceptable but must be removable or capable of being folded down to ensure tent height clearance.

#### 4.3.2 UAV Requirements

During RobotX, the Model Aeronautical Association of Australia (MAAA) will oversee all drone activities during the competition, and are the Australian Civil Aviation Safety Authority (CASA) approved authority at the event venue. For the purposes of this document, the terms Drone, Unmanned Aerial Vehicle (UAV) and model aircraft are used synonymously.

1. The maximum allowable model aircraft category (size) for this competition is small. This category allows model aircraft to be no more than 7kg. Model aircraft that weigh more than this will not be allowed to fly in the competition.
2. All MAAA UAV safety rules will be supplied at a later date.
3. Any instruction given by an MAAA or RobotX staff around the safe operation of drones must be immediately complied with.
4. As UAVs will be operating above water, they must be able to float in freshwater. This will enable recovery in the case of an emergency and will minimize damage to onboard systems.
5. The UAV should be capable of operating in sunny, rain (light or heavy) and varying wind conditions. Although the competition location is normally sunny at this time of year, the competition will continue through these weather conditions.

### 4.3.3 System Management & Monitoring Requirements

1. Each team's AMS 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 have the ability to remotely kill the platform as described in [Section 4.2.3 Kill Switch Requirements](#).
  - c. The AMS must stop operating if it goes out of range from the OCS.
  - d. Teams are required to connect to the Technical Director's Network via the hard-wired RJ45 Ethernet connection, to be provided in the team operations tent. Protocols for this communication are outlined in [Appendix C](#).
  - 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 sections: [Qualifying Round](#), [Semi-Finals Round](#), [Finals Round](#).
  - 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 USV showing operational status. It is strongly recommended the UAV has a clearly visible indicator showing operational status. Specifications for a sample indicator are provided in the [Section 4.2.4 Visual Feedback System Requirements](#). *Note:* These are minimum requirements.
3. Teams are required to implement and provide a graphical display for use by judges as described in the sections: [Qualifying Round](#), [Semi-Finals Round](#), [Finals Round](#).

## 4.4 Obstacle Avoidance

The ability to avoid obstacles is a core capability for unmanned systems. Each buoy on the course represents an object to be avoided or approached in some way. In addition, obstacle buoys may be placed at random throughout the operating areas in an effort to provide a more representative real-world challenge. Figure 25 provides an example of the AMS avoiding the obstacles surrounding the task area.

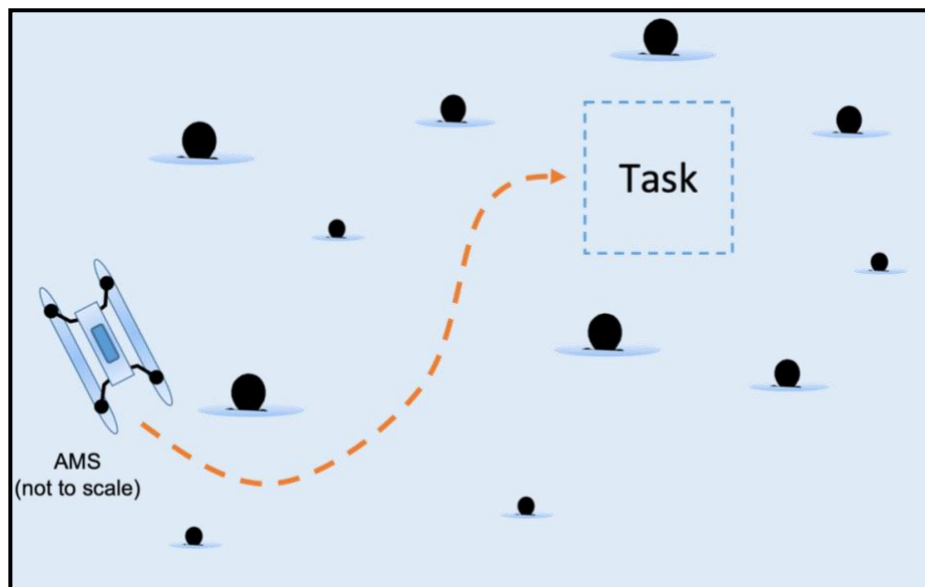


Figure 25: Example Obstacle Avoidance

## SECTION 5: How to Compete

Maritime RobotX Challenge 2022

[www.robotx.org](http://www.robotx.org)

### 5.1 Register and Intent to Compete

#### 5.1.1 Intent to Compete (Closed)

**(February 2022 Update: Intent to Compete is now closed)**

Before the RobotX 2022 Registration opens, teams are invited to complete an Intent to Compete form expressing intent to compete in the 2022 Maritime RobotX Challenge. The Intent to Compete form is available on the RobotX website, [RobotX.org/2022](http://RobotX.org/2022).

RoboNation will provide a hyperspectral camera at no cost to teams. Teams who complete an Intent to Compete form will receive the HSI cameras as soon as they are available. The cameras may be used to accomplish the Wildlife Encounter – React & Report task ([Section 2.5.4](#)). Camera specifications and details are available in [Appendix E: Hyperspectral \(HSI\) Camera](#).

#### 5.1.2 Register to Compete

All teams are required to register to compete using the Registration form found on the RobotX website, [RobotX.org/2022](http://RobotX.org/2022). This registration collects each team's point of contact information, demographics, and the Pre-Competition Requirements outlined in [Section 5.2](#). There is no registration fee.

Teams that complete the Registration form before February 20 are eligible to receive a shipping stipend, up to \$5,000 USD. Eligible teams are required to meet all [shipping deadlines](#) to remain eligible for receiving the stipend.

#### 5.1.3 Data Sharing Access Requirements

During the registration process, teams must provide a generic email account and a team acronym that will be used in the Data Sharing project ([Section 5.6](#)). The generic email can be associated with any email provider. An example of the Generic Email is: [robotx-team@outlook.com](mailto:robotx-team@outlook.com). The team acronym must be within 2-10 characters, abbreviating the team's school or organization. Examples of the team acronym are: RN or ROBOTEAM.

Access will be given to teams that complete the Intent to Compete form and/or Registration form. Only official registered teams will maintain access to the Data Sharing project for the RobotX 2022 season.

### 5.2 Pre-Competition Requirements

These requirements are collected during the registration process, prior to participation on-site at the competition. In addition to the list below, mini challenges may be issued over the next year for which information will be released in future issues of this Team Handbook.

#### 5.2.1 Team Information Package

Teams are required to submit a team list including all participants that support the RobotX 2022 effort, liability waivers, forms, and other contact information.

### 5.2.2 On-Site Requirements

Teams are required to submit battery specifications, a COVID-19 plan, and a shipping plan.

#### Battery Safety Requirements

Teams are required to submit battery specifications, Material Safety Data Sheets (MSDS), and proper disposal procedures, sourced from the battery manufacturer for all batteries. More information can be found in [Section 4.2 Safety](#).

#### COVID-19 Team Plan

Teams are required to submit a COVID-19 Plan prior to arrival. This plan should include:

1. Plan for isolating team members showing COVID-19 symptoms, including plans to obtain/pay for an additional hotel room / isolation area.
2. Plan for testing of team members showing COVID-19 symptoms or those having contact with COVID-19 positive team member.
3. Plan for quarantining team members testing positive for COVID-19, including contingency plans for extended stay until a negative test is received.
4. Emergency plan in case student is hospitalized for COVID-19. Must include:
  - Emergency contact info for all team members.
  - Health insurance / travel insurance information for each team member.
  - Plan for travel home once team member is released from medical care.

*\* Note – RoboNation understands that COVID requirements and protocol are changing rapidly worldwide. The team's plans can change as the competition gets closer. This plan should reflect the possible scenario where a team member is hospitalized and how the team will handle it. These contingencies should be in place for any type of medical emergency for each team, regardless of COVID.*

#### Shipping Plan

Teams are required to submit a shipping plan to facilitate shipment receipt/handling at the competition hotel. Shipping guidelines can be found in [Section 5.4.3 Shipping](#). This shipping plan must include:

1. Box/Crate count (How many total boxes/crates are in the shipment?)
2. Weight of each box/crate
3. Dimensions of each box/crate
4. Name of shipping company used
5. Pick-up Address
6. Return Address
7. Name and contact information for Team Shipping Point of Contact
8. Battery specific provisions for shipments that include batteries.

*(Note: Shipping guidelines for lithium batteries differ by country and by shipping company. Check with your shipping company to determine requirements for shipping new batteries vs. used batteries AND make sure that you are familiar with your shipper's facilities, operating hours, and requirements shipping your vehicle / batteries back home after the competition.)*

#### Pilot Certification

Teams who compete with a UAV are required to submit a logbook of flight hours and a pilot license issued by their respective country, for each pilot. It is recommended for teams to have two Licensed Pilots with one Alternate Pilot. All pilots will be required to do an Australian Drone Operations Safety Test with an MAAA supervisor once on-site at the competition.

### Flight Hour Logbook

Each Pilot is required to provide a logbook of practiced flight hours, including:

- Date
- Aircraft
- Points of Departure/Arrival
- Start/End Times
- Pilot Signature, authenticating the entries are true

### 5.2.3 Design Documentation Package

Teams are required to submit the team website, technical design paper, and team introduction video of their Design Documentation prior to being on-site at the competition. Guidelines can be found in [Section 2.3 Design Documentation](#).

## 5.3 Timeline

Date/Deadline	Event
June – January 2021	Intent to Compete
February – March 31, 2022	Registration
September 25, 2022	Pre-Competition Deadlines: <ul style="list-style-type: none"><li>• Team Information</li><li>• On-Site Requirements</li></ul>
October 2, 2022	Pre-Competition Deadlines: <ul style="list-style-type: none"><li>• Team Information</li><li>• Background Checks (Teams with minor students)</li><li>• Merchandise Order</li></ul>
October 9, 2022	Pre-Competition Deadlines: <ul style="list-style-type: none"><li>• Design Documentation</li></ul>
November 11-17, 2022	RobotX 2022

## 5.4 Logistics

### 5.4.1 Health and Safety

#### COVID-19 Protocols and Local Guidance

The Health and Safety of the RoboNation community is our number one priority. RoboNation follows all local and state health guidelines. We will continue to communicate any changes to on-site protocols as we approach RobotX 2022. Please follow safety guidelines at work, at home, and in the community to help slow the spread of coronavirus.

Updated rules and restrictions for travel to Australia are available on the Australian Government's COVID-19 website, [covid19.homeaffairs.gov.au](https://covid19.homeaffairs.gov.au). Once teams have arrived in Australia, state rules around COVID-19 apply, the NSW Government's updated COVID rules and restrictions are available at: [www.nsw.gov.au/covid-19/stay-safe/rules/people-in-nsw](https://www.nsw.gov.au/covid-19/stay-safe/rules/people-in-nsw)



### 5.4.2 Travel + Lodging

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

#### Lodging—Hotels

Information on the selected event hotel and reservations will be released in future issues of this Team Handbook.

#### International Travel

*Invitation Letter* – During the registration process, teams are given the opportunity to request an invitation letter issued by RoboNation.

*VISA Process* – It is recommended, for international teams, to use the 'Explore the Different Types of Visas' site: [homeaffairs.gov.au](http://homeaffairs.gov.au) to determine the type of Visit and Tourism visa they require. When asked for a contact in Australia, team members should list any family/friends they have in Australia; however, if a team member does not have any friends/family in Australia, please contact [autonomy@robonation.org](mailto:autonomy@robonation.org) for more information.

### 5.4.3 Shipping

Teams are required to submit a shipping plan. The RobotX staff provides support to ensure that teams' equipment can be received, worked through Australian Customs, and staged for competition. A shipping plan template, shipping address, and point of contact for the RobotX freight forwarder can be found on the [RobotX website](#).

### 5.4.4 On-Site Logistics

#### Venue Requirements

- No glass containers can be used while at the venue.
- Teams may be subject to searches of their equipment/personal effects whilst at the venue.
- All team members must wear official RobotX name tags provided at the start of the event.

#### Team Village

Each team will be provided with a covered working area (6m x 6m) on the island with access to both 240VAC, 10A, 50Hz power and a wireless internet connection. The Team Village resides on a bitumen surface. This is where teams should conduct development, maintenance, and repair of their systems. Batteries may be charged during the day at the Team Village but may not be left charging overnight.

#### Team Course Operating Areas (Shoreline)

Teams will be provided with an area along the shoreline near the course areas where they will be able to set up their shore equipment. This space consists of a tent-covered area (6 tents, each 3.3m x 3.3m) with a single 1.8m long table per tent, 240VAC, 10A, 50Hz power, and a hard-wired Ethernet connection to the Technical Director network. The power provided is for Operator Control Station (OCS) use only and shall not be extended to any platforms on the beach. This space is shared between all teams utilizing the course.

## Power

Standard power outlets in Australia are 240V 10amp outlets. Teams are required to bring adapters for use at the competition site and hotel.

- Power Plugs & Sockets: Travel Adapter Needed? ([power-plugs-sockets.com](http://power-plugs-sockets.com))
- Power plug & outlet Type I ([worldstandards.eu](http://worldstandards.eu))
- Australia Power Adapter - Electrical Outlets & Plugs ([world-power-plugs.com](http://world-power-plugs.com))
- When voltage varies ([electricalconnection.com.au](http://electricalconnection.com.au))



Figure 26: Example Power Outlets

### Adapter Examples:

- Power Adapters ([power-supplies-australia.com.au](http://power-supplies-australia.com.au))
- Adaptor Guide | Country & Voltage Guide ([korjo.com](http://korjo.com))

## Transporting the AMSs at the Competition Venue

At the competition venue, each team will be provided a trailer for the AMS, by the RobotX staff. The trailers must be used when moving the AMS around the event and during launch and recovery using the venue boat ramp.

During launch and recovery and any other movement of the AMS trailer by vehicle, the vehicle must be operated by RobotX staff using an event vehicle. To maneuver around Team Village, teams may move the AMS using the trailer by hand.

## 5.5 Communications

### 5.5.1 Pre-Competition Communications

RobotX teams have a variety of opportunities to interact with each other and the RobotX staff.

#### Team Time Meetings

Leading up to the on-site competition, there are regularly held virtual meetings where teams are asked to have a team representative join. These Team Time meetings are hosted by the RobotX organizers and technical team to provide competing teams with competition updates and the opportunity to ask questions.

#### RobotX Discussion Forum

Outside of the Team Time Meetings, all questions, comments, and suggestions should be posted on the [RobotX Discussion Forum](#). Teams are encouraged to actively participate in the online community and monitor it for the latest news and updates regarding all things RobotX.

**Band App**

The RobotX Community in the Band App is used to keep registered RobotX teams updated on the latest announcements, resources, and special deals throughout the competition season. Each team member is encouraged to download the Band App ([band.us](https://band.us)), available on Android and iOS, and get to know the other RobotX teams. Access information is provided in the team registration process, outlined in [Section 5.1 Register and Intent to Compete](#).

**5.5.2 On-site Communications****Team Lead**

Each team must designate a student team member as their team lead. The team lead is the only person permitted to speak for the team 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.

**Technical Director Team**

The RobotX Technical Director Team is part of the RobotX staff, identified with “Staff” on the back of their RobotX shirts. The RobotX Technical Director Team consists of: Technical Director, Deputy Technical Director, Safety Inspectors, and Course Managers.

**Other RobotX Staff**

The RobotX staff are identified with “Staff” on the back of their RobotX shirts.

**5.5.3 RobotX Website**

The official competition website is [www.RobotX.org/2022](https://www.RobotX.org/2022). This website includes all official documents and a detailed list of the registered RobotX Challenge teams. Helpful resources, past competition results, and other engagement opportunities can be found on this website. Information and documents are updated regularly, and it is the team’s responsibility to check the website for updates.

**5.6 Data Sharing**

A Data Sharing project has been established for registered teams competing in RoboNation’s RoboBoat, RoboSub, and RobotX competitions. This project aims to increase collaboration between teams and to provide access to shared resources and test data to validate and debug the reliability and robustness of teams’ machine vision algorithms. Teams are prohibited to share any harmful code, including any virus, malicious code, or other destructive code. Access information is provided in the team registration process, outlined in [Section 5.1 Register and Intent to Compete](#).

For more information on Data Sharing, visit the RoboNation Data Sharing website: [RobotX.org/data-sharing](https://RobotX.org/data-sharing).

## SECTION 6: Glossary & Acronyms

Maritime RobotX Challenge 2022

[www.robotx.org](http://www.robotx.org)

### 6.1 Glossary

Phrase	Definition
<b>Autonomous Maritime System (AMS)</b>	The entire maritime system, including WAM-V Unmanned Surface Vessel (USV) and any off-board systems deployed from the surface platform, such as the Unmanned Aerial Vehicle (UAV).
<b>Wave Adaptive Modular-Vessel (WAM-V)</b>	An innovative surface craft manufactured by Marine Advanced Robotics and utilized as the primary competition vessel for RobotX teams.
<b>Qualifying and Practice Courses</b>	These courses are designed to provide opportunities to demonstrate proficiency in one task at a time. They contain an instance of each task.
<b>Semi-Finals &amp; Finals Courses</b>	These courses are designed to allow demonstration of autonomous execution of multiple interdependent tasks. They contain an instance of each task.
<b>Team Lead</b>	Designated spokesperson for each team.
<b>Technical Director Team</b>	Technical team that runs the courses, safety inspections, set-up, and tear-down.
<b>RobotX Staff</b>	RobotX support personnel.
<b>Judge</b>	Subject Matter Experts that observe and score the Autonomy Challenge and Design Documentation.
<b>Sponsor</b>	Organizations that provide support to RobotX.

### 6.2 Acronyms

Acronym	Definition
<b>ACMA</b>	Australian Communications and Media Authority
<b>AMS</b>	Autonomous Maritime System
<b>CASA</b>	Australian Civil Aviation Safety Authority
<b>MAAA</b>	Model Aeronautical Association of Australia
<b>MSDS</b>	Material Safety Data Sheets
<b>N/A</b>	Not available
<b>NMEA</b>	National Marine Electronics Association
<b>OCS</b>	Operator Control Station
<b>RGB</b>	Red, Green, Blue
<b>RF</b>	Radio Frequency
<b>RPA</b>	Remotely Piloted Aircraft
<b>SME</b>	Subject matter expert
<b>UAV</b>	Unmanned Aerial Vehicle (the terms drone, and model aircraft are used synonymously in this document)
<b>USV</b>	Unmanned Surface Vessel
<b>WAM-V</b>	Wave Adaptive Modular Vessel

# Appendix A: Light Tower Specifications

Maritime RobotX Challenge 2022

www.robotx.org

## A.1. Description

The light tower consists of three faces. Each face has an RGB matrix panel that indicates 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 with all three faces displaying the color in unison. The panel will cycle through four colors. Each color is displayed for 1 second, then the panel goes black (no color) for 2 seconds until the pattern repeats.

This light sequence begins once the team's AMS enters autonomous mode and starts an operational run for points.

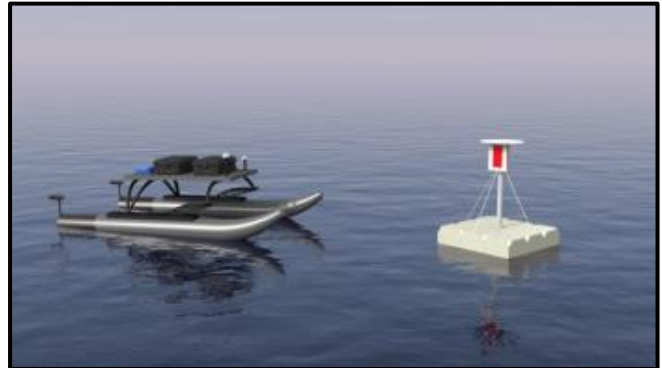


Figure 27. Light Buoy Concept

## A.2. Specifications

The dimensions of one of the three identical faces are shown in Figure 28. The top edge of these faces is between 3m (9.8 feet) and 1m (3.2 feet) above the water. The border around the light bar is white, as illustrated. The structure supporting these faces is subject to change and is not specified here.

## A.3. Parts Source

The LED panels 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 a representative light panel is available at GitHub:  
<https://github.com/madsci1016/RobotXLightBuoy>

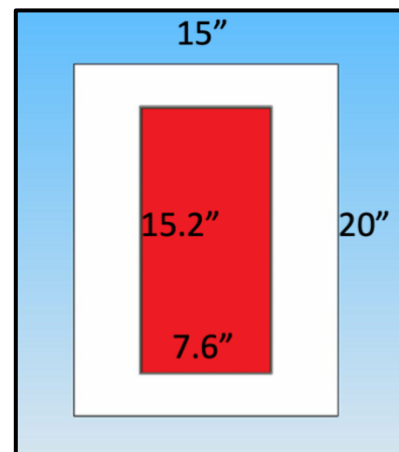


Figure 28. Light Buoy Face

## Appendix B: Beacon Specifications

Maritime RobotX Challenge 2022

[www.robotx.org](http://www.robotx.org)

Each team that plans to attempt the Entrance & Exit Gates task may build a localization system compatible with the competition beacon system. The beacon type and configuration are described in this appendix for reference so that teams may acquire a comparable unit for testing.

### B.1. 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.

Beacon specifications can be found at: [robotx.org/benthos-locator](http://robotx.org/benthos-locator).

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

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



Figure 29: Benthos ALP-365 Beacon



## Appendix C: Communications Protocols

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This appendix describes the communications protocols to report vehicle status and completion of Autonomy Challenge tasks. Each team's implementation of the requirements outlined below may be tested during the competition. RoboNation shall provide support to test this implementation prior to RobotX 2022.

### C.1. Network Information

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

When connected to the Technical Director network, the team's computer must request an IP address from a Technical Director 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 is formatted as an 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 Australian Eastern Daylight Time (AEDT, GMT +11).
- 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 message at a rate more than once per second (1Hz). The vehicle should only transmit one task message at a time, and it should be the task the vehicles is currently on. If any task messages are used for scoring purposes, only the last message for that task transmitted by the vehicle will be considered.

### C.3. Heartbeat Message

The AMS is required to transmit a heartbeat status message at exactly a frequency of 1 Hz. This heartbeat is used to verify the link has been established with the Technical Director Network and competition equipment. In addition, this channel is used to relay information specific to a task during its run attempt. The fields for the heartbeat message are shown in Table 15, and followed by an example heartbeat message.

Name	Example	Description	Notes
<b>Message ID</b>	\$RXHRB	Protocol Header	
<b>AEDT Date</b>	111221	ddmmyy	Use Australian Eastern Daylight Time (AEDT)
<b>AEDT Time</b>	161229	hhmmss (24hr time format)	Use Australian Eastern Daylight Time (AEDT)
<b>Latitude</b>	21.31198	Decimal degrees	Provides ~1.11m accuracy
<b>N/S indicator</b>	N	N=north, S=South	
<b>Longitude</b>	157.88972	Decimal degrees	Provides ~1.04m accuracy
<b>E/W indicator</b>	W	E=east, W=west	
<b>Team ID</b>	ROBOT	Team ID	5-character code assigned by Technical Director
<b>System Mode</b>	2	Current mode of AMS 1=Remote Operated 2=Autonomous 3=Killed	
<b>UAV Status</b>	1	Current UAV Status 1=Stowed 2=Deployed 3=Faulted	The 'Stowed' state used only when the UAV is secured to the USV. The 'Deployed' state is used whenever the UAV is not on board the USV. The 'Faulted' state is used whenever the UAV is not functioning as designed.
<b>Checksum</b>	11	Bitwise XOR	
<CR><LF>		End of message	

Table 15. RobotX 2022 Heartbeat Message Fields

Heartbeat Example Message: \$RXHRB,111221,161229,21.31198,N,157.88972,W,ROBOT,2,1\*11

## C.4. Entrance and Exit Gates Message

The Entrance and Exit Gates message provides a method for the AMS to report the gate where it detects an active beacon using the protocol specified in Table 16. An example is provided below the table. When the AMS transmits this message the Technical Director system echoes the received message back to verify transmission.

Name	Example	Description
Message ID	\$RXGAT	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	ROBOT	5-character code assigned by Technical Director
Active Entrance Gate	1	Gate 1, 2, or 3
Active Exit Gate	2	Gate 1, 2, or 3
Checksum	3C	Bitwise XOR
<CR><LF>		End of message

Table 16. Entrance and Exit Gate Message Fields

Entrance and Exit Gate Example Message:      \$RXGAT,111221,161229,ROBOT,1,2\*3C

## C.5. Follow the Path Message

The Follow the Path task requires that the AMS navigate a path defined by pairs of buoys. The AMS may report when it has completed the path using the protocol specified in Table 17. An example is provided below the table. When the AMS transmits this message the Technical Director system echoes the received message back to verify transmission.

Name	Example	Description
Message ID	\$RXPTH	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	ROBOT	5-character code assigned by Technical Director
Finished	1	1 = In Progress 2 = Completed
Checksum	3C	Bitwise XOR
<CR><LF>		End of message

Table 17. Follow the Path Message Fields

Follow the Path Example Message:      \$RXPTH,111221,161229,ROBOT,1\*3C

## C.6. Wildlife Encounter – React and Report Message

The Wildlife Encounter – React and Report task requires that the AMS identify and classify ‘wildlife’ objects with a UAV and circle the objects according to their classification. The AMS may report the number of ‘wildlife’ objects detected and their classification using the protocol specified in Table 18. An example is provided below the table. When the AMS transmits this message the Technical Director system echoes the received message back to verify transmission.

Name	Example	Description
Message ID	\$RXENC	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	ROBOT	5-character code assigned by Technical Director
Num Detected	3	1, 2 or 3 ‘wildlife’ objects detected
1st Wildlife	P	Classification of 1st Wildlife Object P=Platypus, C=Crocodile, T=Turtle
2nd Wildlife	C	Classification of 2nd Wildlife Object P=Platypus, C=Crocodile, T=Turtle
3rd Wildlife	T	Classification of 3rd Wildlife Object P=Platypus, C=Crocodile, T=Turtle
Checksum	51	Bitwise XOR
<CR><LF>		End of message

Table 18. Wildlife Encounter – React and Report Message Fields

Wildlife Encounter Example Message: \$RXENC,111221,161229,ROBOT,3,P,C,T\*51

## C.7. Scan the Code Message

The Scan the Code task requires that the AMS locate and observe a light tower to determine the light sequence displayed. The AMS may transmit the detected light pattern using the protocol specified in Table 19. An example is provided below the table. When the AMS transmits this message the Technical Director system echoes the received message back to verify transmission.

Name	Example	Description
Message ID	\$RXCOD	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	ROBOT	5-character code assigned by Technical Director
Light Pattern	RBG	Colors identified from first to last, over time R=red, B=blue, G=green
Checksum	5E	Bitwise XOR
<CR><LF>		End of message

Table 19. Scan the Code Message Fields

Scan the Code Message Example: \$RXCOD,111221,161229,ROBOT,RGB\*5E

## C.8. Detect and Dock Message

The Detect and Dock task requires the AMS to identify an assigned colored vinyl panel and dock the AMS in the corresponding docking bay. The AMS may report the detected color of the face where it docks using the protocol specified in Table 20. An example is provided below the table. When the AMS transmits this message the Technical Director system echoes the received message back to verify transmission.

Name	Example	Description
Message ID	\$RXDOK	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	ROBOT	5-character code assigned by Technical Director
Color	R	Color of the docking bay being attempted R=red, B=blue, G=green
AMS Status	1	Status of the AMS 1=Docking, 2=Complete
Checksum	4E	Bitwise XOR
<CR><LF>		End of message

Table 20. Detect and Dock Message Fields

Detect and Dock Example Message: \$RXDOK,111221,161229,ROBOT,R,1\*4E

## C.9. Find and Fling Message

The Find a Fling task requires the AMS to identify an assigned colored vinyl panel and deliver a payload into one of the holes. The AMS may report the detected color of the face where it delivers its payload using the protocol specified in Table 21. An example is provided below the table. When the AMS transmits this message the Technical Director system echoes the received message back to verify transmission.

Name	Example	Description
Message ID	\$RXFLG	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	ROBOT	5-character code assigned by Technical Director
Color	R	Color of the shape on the face being targeted R=red, B=blue, G=green
AMS Status	1	Status of the AMS 1=Scanning, 2=Flinging
Checksum	40	Bitwise XOR
<CR><LF>		End of message

Table 21. Find and Fling Message Fields

Find and Fling Example Message: \$RXFLG,111221,161229,ROBOT,R,2\*40

## C.10. UAV Replenishment Message

The UAV Replenishment task requires that the AMS use the UAV to pick up an item from the dock and deliver it to a floating helipad. The AMS may report when the UAV deploys, picks up the item, and delivers the item using the protocol specified in Table 22. An example is provided below the table. When the AMS transmits this message the Technical Director system echoes the received message back to verify transmission.

Name	Example	Description
<b>Message ID</b>	\$RXUAV	Protocol Header
<b>AEDT date</b>	111221	ddmmyy
<b>AEDT time</b>	161229	hhmmss
<b>Team ID</b>	ROBOT	5-character code assigned by Technical Director
<b>UAV Status</b>	Current status 1=Stowed 2=Deployed 3=Faulted	The 'Stowed' state is used only when the UAV is secured to the USV. The 'Deployed' state is used when the UAV is not on board the USV. The 'Faulted' state is used when the UAV is not functioning as designed.
<b>Item Status</b>	Current status 0=Not Picked Up 1=Picked Up 2=Delivered	The 'Not Picked Up' state is used when the item has not been picked up by the UAV. The 'Picked Up' state is used upon successful pick-up of the item by the UAV. The 'Delivered' state is used upon successful delivery of the item by the UAV.
<b>Checksum</b>	2C	Bitwise XOR
<b>&lt;CR&gt;&lt;LF&gt;</b>		End of message

Table 22. UAV Replenishment Message Fields

UAV Replenishment Example Message: \$RXUAV,111221,161229,ROBOT,2,1\*2C

## C.11. UAV Search and Report Message

The UAV Search and Report task requires the UAV to launch from a designated start point, conducts a search of a field marked by four orange buoys, detects and determines the location of 2 distinct objects in the field, and lands at the designated end point. Teams may implement any search pattern; however, the UAV must stay within the boundary of the task. using the protocol specified in Table 23. An example is provided below the table. When the AMS transmits this message the Technical Director system echoes the received message back to verify transmission.

Name	Example	Description
Message ID	\$RXSAR	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Object being reported	R	"R" or "N"
Object Latitude	21.31198	Decimal degrees
N/S indicator	N	N=north, S=south
Object Longitude	157.88972	Decimal degrees
E/W indicator	W	E=east, W=west
Object being reported	N	"R" or "N"
Object Latitude	21.31198	Decimal degrees
N/S indicator	N	N=north, S=South
Object Longitude	157.88972	Decimal degrees
E/W indicator	W	E=east, W=west
Team ID	ROBOT	5-character code assigned by Technical Director
UAV Status	Current status 1=Manual 2=Autonomous 3=Faulted	The 'Manual' state is used only when the UAV is under manual control. The 'Autonomous' state is used when the UAV operating autonomously. The 'Faulted' state is used when the UAV is not functioning as designed.
Checksum	0D	Bitwise XOR
<CR><LF>		End of message

Table 23. UAV Search and Report Message Fields

UAV Search and Report Example Message:

\$RXSAR,111221,161229,R,21.31198,N,157.88972,W,N, 21.32198,N,157.89972,W,ROBOT,2\*0D



# Appendix D: Radio Communication Restrictions

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Radio communication is managed under the restrictions laid out in the Radio Communication Class Licenses controlled by the Australian Communication and Media Authority (ACMA).

In Australia, Class Licenses let you operate common radio equipment on shared frequencies without needing to get additional approval and alleviate the requirement to have specific qualifications. Each class license tells you:

- What equipment you can use under the license;
- The permissible frequency range; and
- The rules for using it.

The relevant class licenses have been summarized below. Whilst every attempt has been made to ensure the below details are correct, the authoritative sources are the class licenses located in the links.

## D.1. Class Licenses

### D.1.1 Intelligent Transport Systems Class License (SHF)

This class license lets you operate an intelligent transport systems (ITS) station. ITS uses wireless technology for vehicles and traffic systems to communicate from:

- Vehicle to person
- Vehicle to vehicle
- Vehicle to structure

The following restrictions apply:

- SHF: 5855MHz to 5925MHz
- Radiated power does not exceed a maximum EIRP of 23dBm/MHz
- <https://www.acma.gov.au/licences/intelligent-transport-systems-class-licence>

### D.1.2 Radio-Controlled Models Class License (HF/VHF)

This class license lets you use radio equipment to control model planes, trains, cars, and boats. All users operate on shared frequencies. The following restrictions apply:

- HF: 29MHz band (29.72MHz to 30MHz)
- VHF: 36 MHz band (36MHz to 36.6MHz)
- Maximum EIRP greater than 300 milliwatts and not exceeding 1 watt
- <https://www.acma.gov.au/licences/radio-controlled-models-class-licence>

### D.1.3 Citizen-Band Radio Stations Class License (HF/UHF)

This class license lets you use citizen band (CB) radios to communicate over short distances. The following restrictions apply:

- HF: 26.965MHz to 27.405MHz (inclusive)
- UHF: 476.4125MHz to 477.4125MHz (inclusive)
- <https://www.acma.gov.au/licences/citizen-band-radio-stations-class-licence>

#### D.1.4 Low Interference Potential Devices (LIPD) Class License (MF/VHF/UHF/SHF)

This class license lets you use some short-range devices on shared frequencies. These include:

- Wi-Fi devices
- Telecommand for drones
- Radars including automotive
- Ultra-wideband transmitters
- Infrared equipment
- Video sender transmitters

The following restrictions apply:

- <https://www.acma.gov.au/licences/low-interference-potential-devices-lipd-class-licence>

#### D.1.5. Radio Navigation Satellite Service Class License

This class license lets you use radio navigation satellite service receivers. These are commonly called GPS (Global Positioning System) receivers.

The following restrictions apply:

- You can only receive RNSS signals on the frequencies listed in the class license:
  - 1164 to 1215MHz
  - 1215 to 1240MHz
  - 1240 to 1300MHz
  - 1559 to 1610MHz
- <https://www.acma.gov.au/licences/radio-navigation-satellite-service-class-licence>

## Appendix E: Hyperspectral (HSI) Camera

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OpenHSI is a complete camera and software hyperspectral imaging system developed by staff and students at the University of Sydney, originally funded by The Commonwealth of Australia's Defence Science and Technology Group (DSTG), Maritime Division. Ongoing work is currently funded by DSTG's StarShot program on Remote Undersea Surveillance as part of the 'More Together' Strategy.



Figure 30: RoboNation Hyperspectral Camera

The goal of the OpenHSI project is to proliferate deeper understanding of Hyperspectral Imaging Spectroscopy through making the system open and providing best practice tools to create (3D print and assemble), calibrate and operate an imager, that is affordable for Science and Engineering specialists in Remote Sensing. To this end, the software uses OpenSource tools as much as possible including NASA's 6S radiative transfer model through the Py6S python software.

The University of Sydney's Associate Professor Sergio Leon-Saval and Dr. Christopher Betters of the Sydney Astrophotonic Instrumentation Laboratory (SAIL) developed the first OpenHSI camera from previously published designs, adapting it to readily available materials, and thus incrementally changing the design, at the request of Dr. Bradley Evans and his team from DSTG.

The Australian Research Council funded training centre CubeSats, UAV and their applications (CUAVA) students Yiwei Mao (PhD Candidate) and Samuel Garske (PhD candidate) developed their software to support the camera as part of their PhD and have publications pending on their work. Professors Iver Cairns and Associate Professor K.C.Wong and Dr. Bradley Evans supervise Yiwei and Sam.

RoboNation, together with DSTG and funded by the Next Generation Technologies Fund, will incorporate a version of the OpenHSI system in the Australian based event.

Since the project commenced, Sydney Photonics Pty Ltd was founded by Dr. Christopher Betters to commercialize the technology and will supply competitors in the upcoming RobotX Challenge with OpenHSI cameras developed for RobotX.

Join us in making use of this technology, help us enhance the communities understanding of hyperspectral imaging spectroscopy. We encourage you to participate in the community and support the work of the OpenHSI team.

## E.1. Python Library

<https://github.com/openhsi/openhsi/tree/master/>

PyPi <https://pypi.org/project/openhsi/>

## E.2. Documentation and Tutorials

<https://robotx.org/2022#resources>

<https://openhsi.github.io/openhsi/>

Forum Support: <https://robonationforum.vbulletin.net/forum/robotx/-2022-robotx-challenge>