

# Task Descriptions and Specifications

*Maritime RobotX Challenge 2022*

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

## 1. Introduction

This document presents the detailed task descriptions and specifications for the 2022 Maritime RobotX Challenge, which will be conducted 11-17 November 2022 at the Sydney International Regatta Centre, Penrith in New South Wales, Australia.

The 2022 Maritime RobotX Challenge Rules and Requirements are available on the official competition website. The official competition website is [www.RobotX.org/2022](http://www.RobotX.org/2022). The 2022 documents posted on [www.RobotX.org/2022](http://www.RobotX.org/2022) are the official documents for the 2022 competition. All documents referenced here and in other RobotX documents are also available at the official competition website. These documents are updated regularly. Teams are responsible for checking the website for the most recent revisions.

The term **AMS** will be used through this document to mean the Autonomous Maritime System (AMS) and any ancillary (offboard) subsystems used to accomplish the tasks. It will be necessary for teams to develop a System of Systems (SoS) consisting of systems and subsystems operating in multiple domains. All teams must use the Wave Adaptive Modular Vessel (WAM-V) Unmanned Surface Vehicle but will also need the ability to collaboratively sense and act aurally through the use of an Unmanned Aerial Vehicle.

## 2. Goals

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

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

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

### 3. Competition Structure

#### 3.1 Overall Approach

The competition is structured to include several autonomous performance challenges and technical documentation, as well as communications requirements. The in-water challenges provide an opportunity to demonstrate system performance. The technical documentation requirements provide an opportunity for teams to present their work to the judges and explain their design philosophy. The communication requirements help improve Technical Director, Judge, and observer understanding of what is happening. An overview of these requirements is given in the *RobotX Project Deliverables and Presentations* section.

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

The venue is large enough to support installation of multiple instances of each task in which teams may practice and qualify for spaces in the Semi-finals round. The proposed layout for the three challenge courses is shown in Figure 1 and Figure 2. The final layouts are under development and are therefore subject to change.

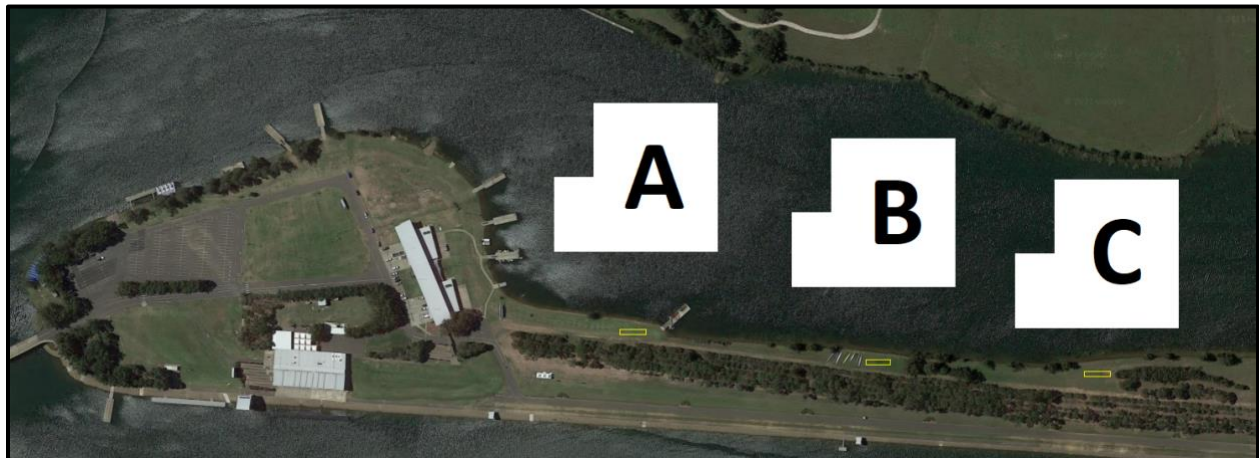


Figure 1: Proposed Course Layout (subject to change)

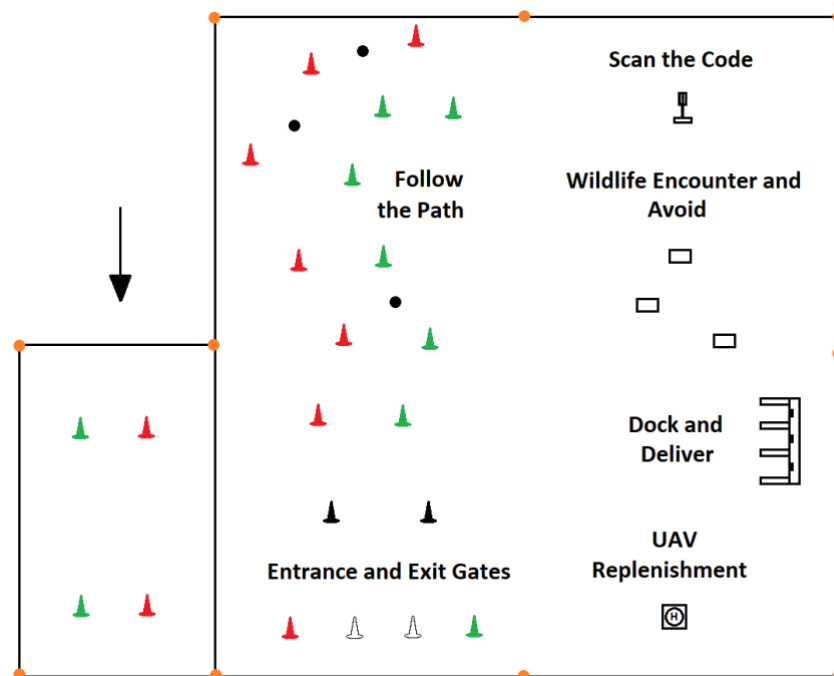


Figure 2: Proposed Course Layout (subject to change)

Note that the following caveats apply:

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

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

### 3.1.1 Challenge Courses (Practice / Qualifying Areas)

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

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

Once a team has successfully demonstrated proficiency on individual tasks of the Challenge Course, they will be qualified for the Semi-finals round and become eligible to sign up for time slots on a Competition Course as described in Section 3.1.2.

The practice/qualifying areas will be available for teams to schedule and use throughout the competition. The schedule will be presented to teams during the on-site orientation.

### 3.1.2 Competition Course (Semi-finals and Finals)

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

### 3.1.3 Team Lead

Each team must designate a student team member as their team lead. The team lead is the only person allowed to speak for the team. The team lead is the only person permitted to request vehicle deployment, run start, run end, or vehicle retrieval. The team lead must be conversationally fluent in English to communicate with RobotX staff. Teams who do not have members fluent in English should contact RobotX staff as soon as possible.

## 3.2 Planned Sequence of Events

This section summarizes the main daily events during the 2022 Maritime RobotX Challenge.

### 3.2.1 Event Phases

There are three (3) phases to the 2022 Maritime RobotX Challenge:

- During the Practice and Qualifying phase, teams will be given time to assemble and test their unmanned systems, participate in initial safety inspections, practice, and qualify for Semi-finals in the water on the **Challenge Courses**.
- During the Semi-finals Round, teams will have the opportunity to advance to the Finals Round by completing runs on the **Competition Courses**. Only teams that have qualified for the Semi-finals will have access to the Competition Courses. Teams that have qualified for the Semi-finals may also continue to use the Challenge Course for practice on individual tasks.
- The finals Round will be held on **17 November 2022**.

### 3.2.2 Daily Events

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

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

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

### 3.3 Judging and Scoring Guidance

Detailed task scoring breakdowns are in development. They will be provided in a separate document, *2022 Maritime Challenge RobotX Scoring Guidance*. Scores will be calculated by the Judges, and all decisions of the Judges are final.

### 3.4 Team Operations

The 2022 Maritime RobotX Challenge will be setup along the shore and in the water on the northern side of the Sydney International Regatta Centre Island.

#### 3.4.1 Team Village

Each team will be provided with a covered working area on the island which will have access to both 240VAC, 10A, 50Hz power and a wireless internet connection. The Team Village resides on a flat 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.

#### 3.4.2 Team Course Operating Areas (shoreline)

Teams will be provided with an area along the shoreline near the course areas in which they will be able to set up their shore equipment. This space will consist of a tent-covered area (6 tents, each 3m x 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.

#### 3.4.3 Transporting the AMSs at the Competition Venue

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

#### 3.4.4 Safety Considerations

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

If a RobotX staff member determines that there is an unsafe condition present or imminent, that person may activate the kill switch. The RobotX staff member is not required to advise the team prior to the decision to terminate the run attempt. In this and all other matters of safety, the decisions of the RobotX staff are final.

## 4. Qualifying for Course Entry

Prior to entering any of the challenges, teams must demonstrate their ability to safely control their Wave Adaptive Modular Vehicle (WAM-V) and their Unmanned Aerial Vehicle (UAV).

### 4.1 WAM-V Static Safety Inspection

Prior to being allowed on the water, teams must showcase they have met all the safety requirements for water operations. Documentation listing these safety checks will be provided separately.

### 4.2 WAM-V Dynamic Qualifying Task

Teams must demonstrate that the WAM-V can maintain positive control and effectively detect and navigate the channel markers. This is a **MANDATORY TASK** and is a minimum requirement for course entry during practice, qualifying, semi-final and final days.

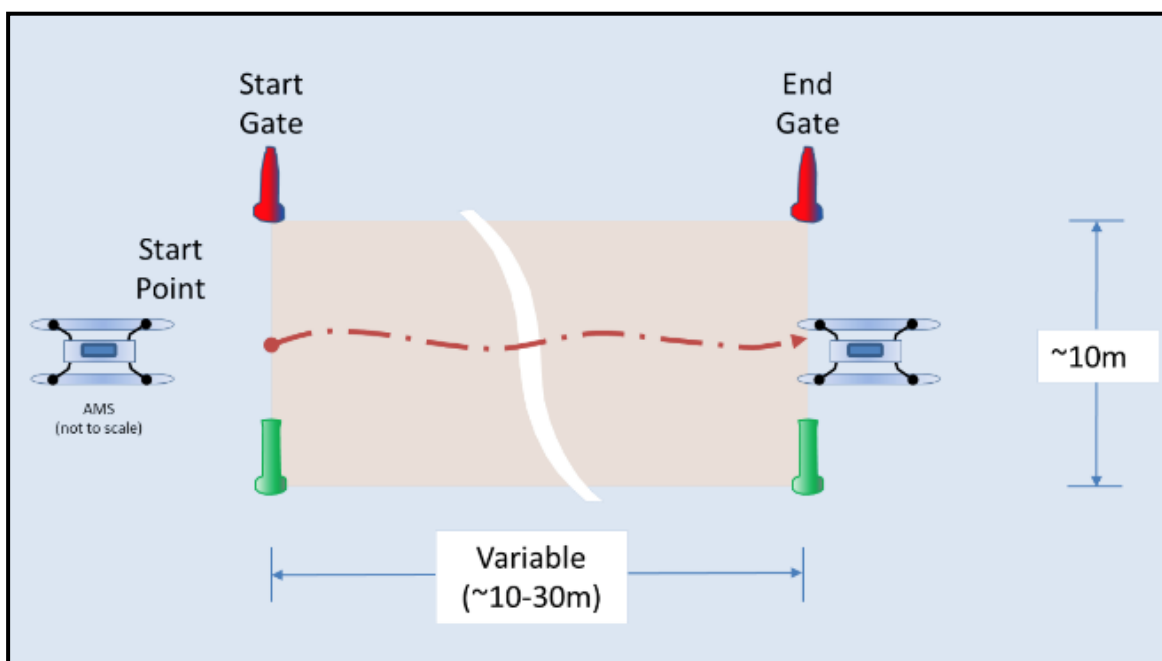


Figure 3: Dynamic Safety Inspection

#### 4.2.1 Detailed Task Description

The AMS must successfully navigate through two pairs of red and green buoys in a fully autonomous manner, demonstrating effective control of the system (see Figure ). Successful completion of this task will allow the AMS to proceed to the team's assigned area and enable entry to the courses for practice, qualifying, semi-finals and finals. After demonstrating this capability, the AMS will be allowed to proceed to the team's assigned area. Demonstration of this task each time the AMS is re-deployed in the water.

### 4.2.2 Task Elements

Planned task elements for this task are detailed in Table 1 below.

**Table 1: Task Elements for Dynamic Safety Inspections**

Task Element	Description	Model No.	Ht. Above Waterline	Base Diam.
<b>Start Gate Port Marker</b>	650mm Dia. Marker Buoy (Red) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>Start Gate Starboard Marker</b>	650mm Dia. Marker Buoy (Green) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>End Gate Port Marker</b>	650mm Dia. Marker Buoy (Red) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>End Gate Starboard Marker</b>	650mm Dia. Marker Buoy (Green) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm

## 4.3 Unmanned Aerial Vehicle Static Safety Inspection

Teams must demonstrate that their UAV can pass a static safety inspection prior to being given flight clearance for aerial operations. Documentation listing these safety checks will be provided separately.

## 4.4 Unmanned Aerial Vehicle Dynamic Qualifying Task

Teams must demonstrate that the UAV can autonomously launch, search a marked field for objects, display rendered RGB images of the objects, and land safely (see Figure 4). This qualifying task will be completed by teams on shore prior to teams being granted clearance for over-water operations.

### 4.4.1 Detailed Task Description

Teams must demonstrate that the UAV can complete this task prior to the UAV entering the challenge courses. The UAV must launch from a designated start point and conduct a search of a field. Teams can implement any search pattern; however, the UAV must stay within the boundary. The boundary will be marked with four orange buoys which are the same buoys used in the Challenge tasks.

When conducting the search, the UAV must detect two objects marked with a RoboNation 'R' and an 'N' (80% grey color logos on 20% grey color background), capture a hyperspectral image of the objects and render as an RGB image. These must be displayed to the judges. The example of a swath from the hyperspectral camera is at Figure 5. Note: ground sampling distance will be finer than illustrated.



On completion of the search, the UAV will land at the finishing point outside the field boundary as shown in **Error! Reference source not found..**

The UAV must also be able to demonstrate a 'return to home' capability that over-rides all other commands. Successful completion of this task will allow the UAV to proceed to the team's assigned area and enable entry to the courses for practice, qualifying, semi-finals and finals.

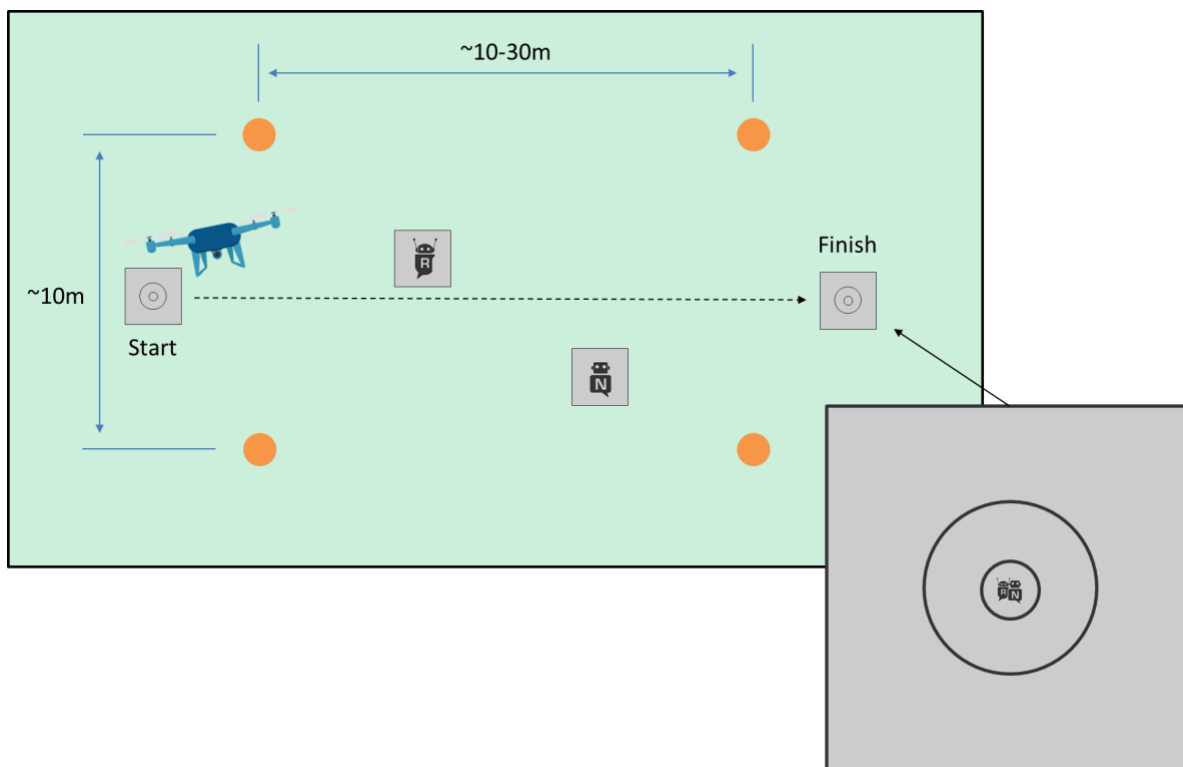


Figure 3: UAV Dynamic Qualifying Task

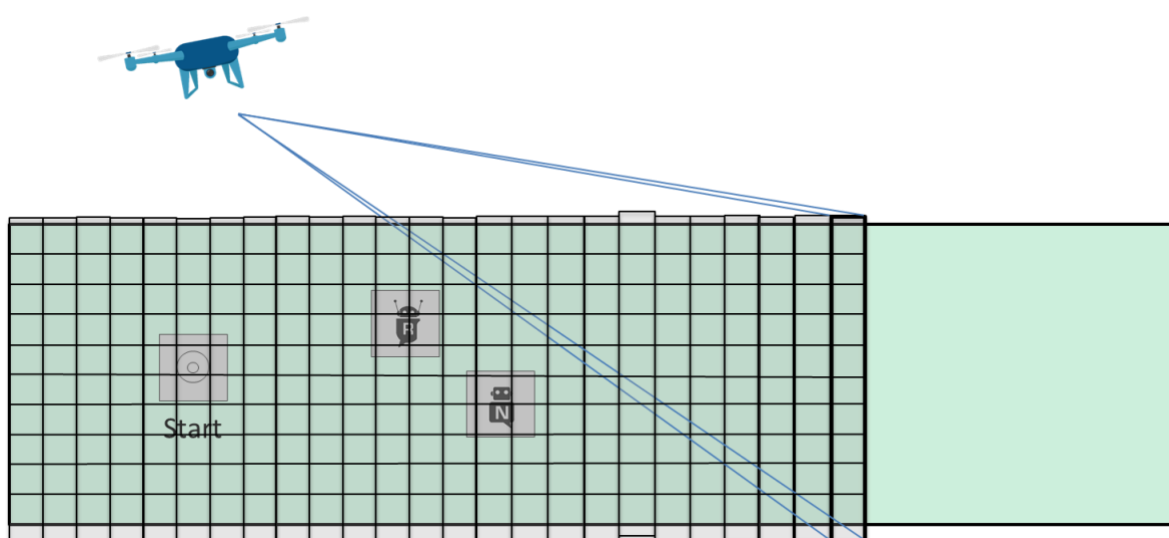


Figure 4: Example Swath from Line Scanning HSI Camera



#### 4.4.2 Task Elements

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

**Table 2: Task Elements for Dynamic Safety Inspections**

Task Element	Description	Model No.	Ht. Above Waterline	Base Diam.
<b>Field Boundary Marker</b>	470mm Dia. Round Foam Filled Barrier Buoy (Orange) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A		
<b>Objects</b>	1m x 1m Flat, white marker with 'X' or 'O' symbol	N/A		

## 5. RobotX Challenge Tasks

This section provides details of the individual RobotX 2022 Challenge tasks. For practice/qualifying days, teams will attempt the tasks individually. For the Semi-finals and Final Rounds, the tasks may be combined into new, multi-tier tasks. Potential combinations of the tasks for the Semi-Finals and Finals will be released at a later date.

Autonomous station keeping and controlled maneuvering are capabilities that enable successful completion of several tasks in the 2022 Maritime RobotX Challenge. Light contact with some course elements may be permitted; the Technical Director's team and judges may require teams to end their attempt if they determine that the AMS is in danger of damaging course elements.

### 5.1 Challenge Task 1 - Entrance and Exit Gates

A set of three gates will be located in the course area with a beacon placed underwater within each gate. The AMS must detect the active underwater beacon, transit through the gate in which the active beacon is located, and then circle one of two buoys.

#### 5.1.1 Detailed Task Description

There will be four marker buoys designating the three gates: Gate 1 will be bounded by a red buoy and a white buoy; Gate 2 will be bounded by two white buoys; and Gate 3 will be bounded by a white buoy and a green buoy (see Figure 6). In the middle of each gate, there will be a submersed beacon. The Beacon to be used is the Teledyne Benthos ALP-365 Pinger used in previous years. Beacon specifications are available in Appendix A: Beacon Specifications. The space between the ENTRY and EXIT gates will be approximately 10m.

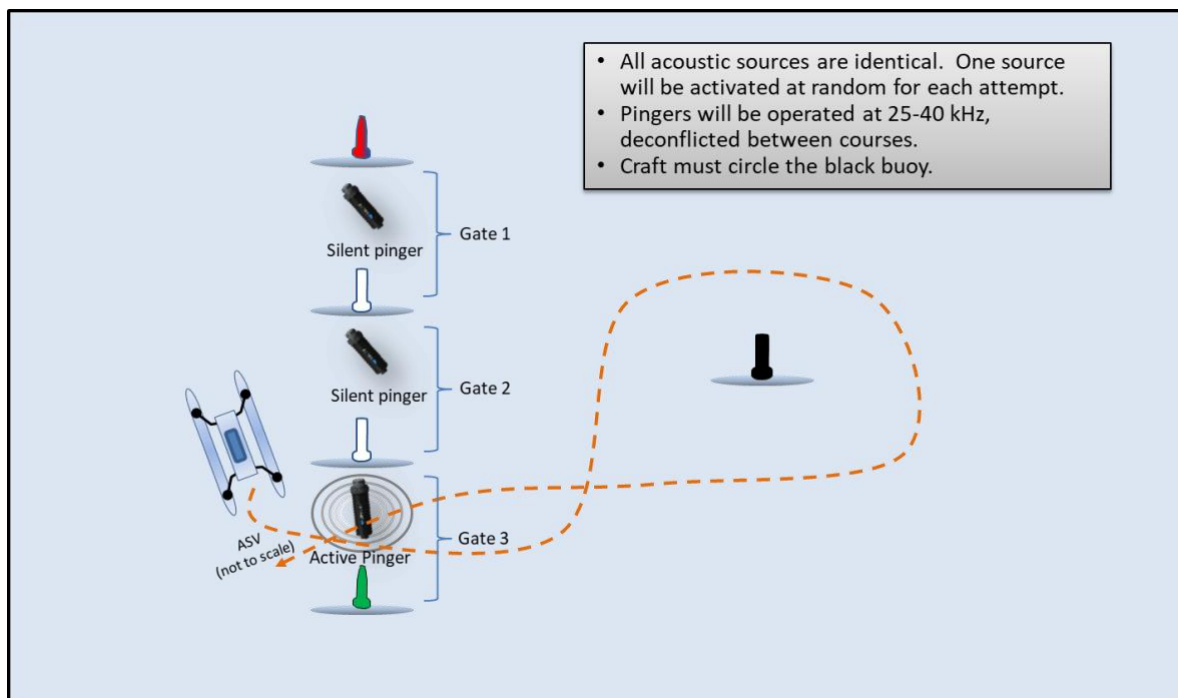


Figure 5: Example Entrance and Exit Gate Task

### Qualifying Round

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

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

### Semi-final and Final Rounds

For the Semi-finals and Finals rounds, the gates will serve as the entrance and exit point for the Competition Courses. A single beacon will be activated at the start of each run to indicate the correct EXIT GATE. The AMS must detect and pass through the gate with the active beacon to exit the course. There will be no black buoy to circle for the Semi-final and Finals rounds.

#### 5.1.2 Task Elements

Proposed task elements for the Entrance and Exit Gates task are detailed in Table 3.

Table 3: Task Elements for Entrance and Exit Gates

Task Element	Description	Model No.	Ht. Above Waterline	Base Diam.
<b>Port Marker</b>	650mm Dia. Marker Buoy (Red) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>Middle Marker (1 of 2)</b>	650mm Dia. Marker Buoy (White) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>Middle Marker (2 of 2)</b>	650mm Dia. Marker Buoy (White) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>Starboard Marker</b>	650mm Dia. Marker Buoy (Green) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>Buoy to Circle</b>	650mm Dia. Marker Buoy (Black) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm

## 5.2 Challenge Task 2 – Follow the Path

This task is modelled after the “Traverse Navigation Channel” task from the 2019 Virtual RobotX Competition and will involve the AMS navigating a path defined by pairs of buoys with the assistance of a UAV to map the challenge task.

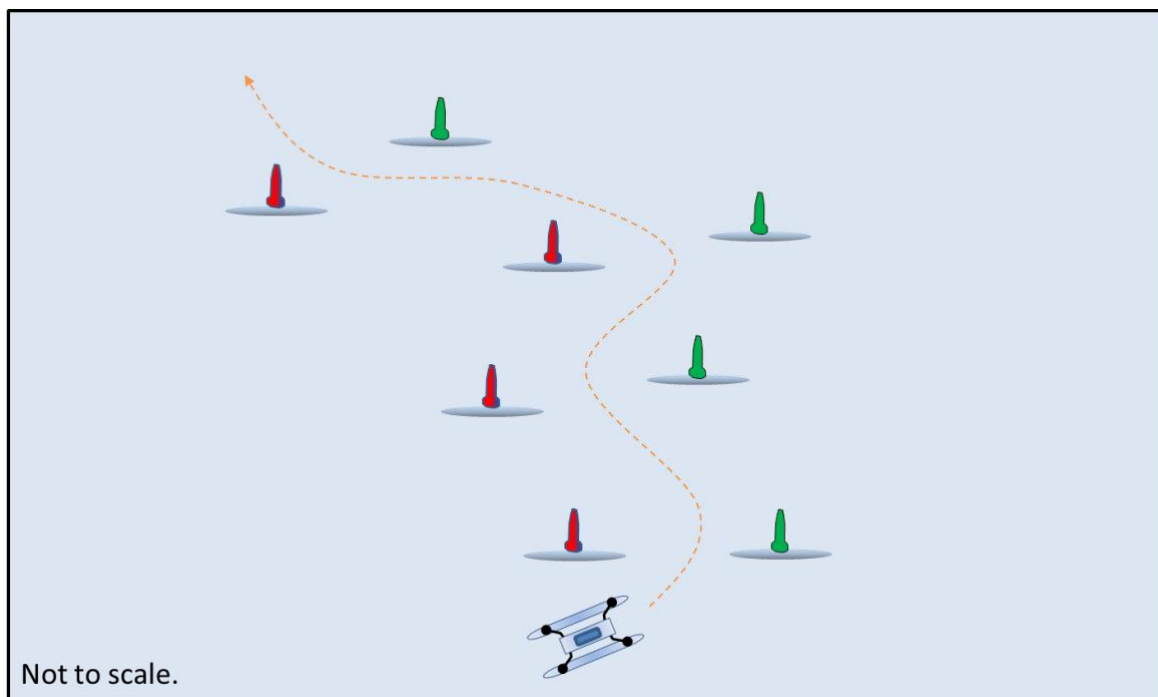


Figure 6: Follow the Path [example]

### 5.2.1 Detailed Task Description

The path will be defined by 6 pairs of buoys. Each pair will consist of a red and green colored buoy (see Figure 7). The exact buoy types may vary from what was used in the Virtual RobotX competition (see Table 4). Obstacles may be included within and around the path.

#### *Qualifying Round, Semi-final and Final Rounds*

For all rounds, the AMS must navigate through a path defined by sets of buoys, where each set is a pair of red/green colored buoys. In this challenge, there will be a number of obstacles in the field which will be marked by four white buoys (listed in Table 4). The AMS must transit through the path marked by the pairs of red/green colored buoys without striking any obstacle. The AMS may choose to deploy a UAV to map the challenge task. Multi-domain vehicle cooperation is encouraged and may incur additional points. Refer to the Scoring Guidance document for more specific information.

### 5.2.2 Task Elements

Proposed task elements for the Follow the Path task are detailed in Table 4.

**Table 4: Task Elements for Follow the Path**

Task Element	Description	Model No.	Ht. Above Waterline	Base Diam.
<b>Field Boundary Marker</b>	470mm Dia. Round Foam Filled Barrier Buoy (Orange) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A		
<b>Start Gate Port Marker</b>	650mm Dia. Marker Buoy (Red) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>Start Gate Starboard Marker</b>	650mm Dia. Marker Buoy (Green) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A	850mm	650mm
<b>Obstacle</b>	470mm Dia. Round Buoy (Black) Supplier: Marine Buoys Australia <a href="http://www.marinebuoysaustralia.com">www.marinebuoysaustralia.com</a>	N/A		

### 5.3 Challenge Task 3 - Wildlife Encounter and Avoid

The Wildlife Encounter and Avoid task will be similar to the Find the Totems task in the 2018 RobotX Challenge except it will incorporate Hyperspectral Imaging Spectroscopy and a UAV.

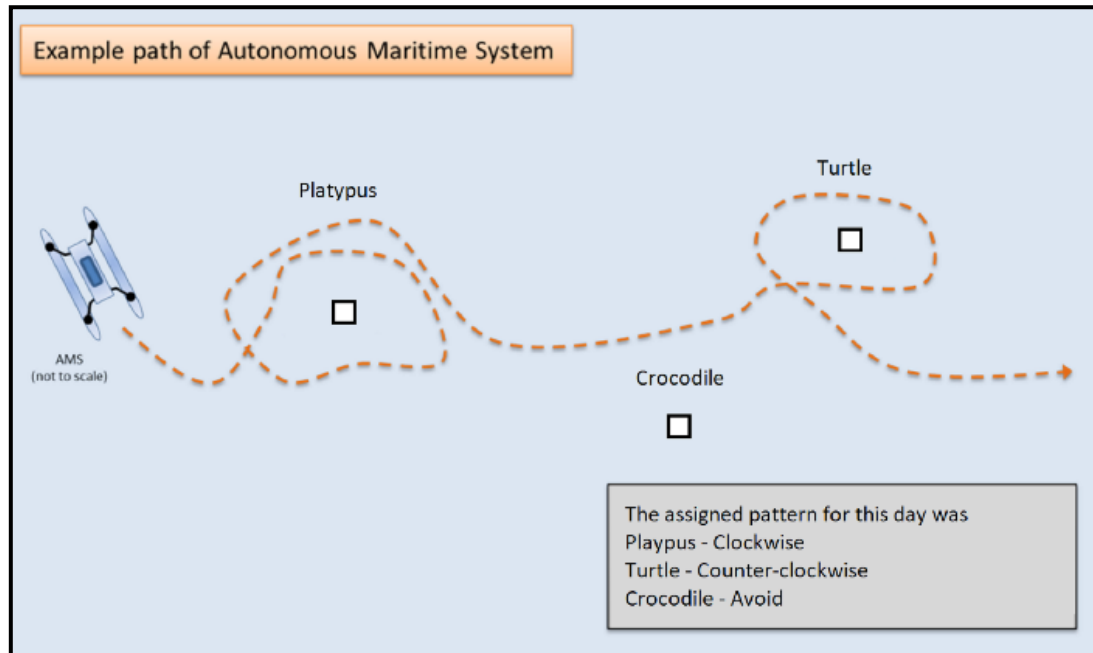


Figure 7: Wildlife Encounter and Avoid

#### 5.3.1 Detailed Task Description

The Wildlife Encounter and Avoid task requires the UAV to identify specific objects of interest and inform the WAM-V to circle or avoid the object accordingly. These objects of interest will represent Australian Marine Life such as platypuses, turtles and crocodiles and will each be painted in distinct coatings with unique spectral signatures to enable identification and classification with a hyperspectral camera. These objects of interest will be flat pieces of plywood with these different coatings applied to distinguish them from each other. To an RGB camera, these objects will look the same.

In order to receive points for this task, teams will be required to submit any and all data and imagery collected by their system at the end of their run. The format and submission timeline of this data will be specified at a later date.

#### *Qualifying Round, Semi-final and Final Rounds*

For all rounds, the UAV must launch from and return to the WAM-V and survey the challenge. It must provide information back to the Technical Director Station, identifying the objects and classifying them as either platypuses, turtles or crocodiles.

Based on the identification and classification of the object, the WAM-V must either circle or avoid the object accordingly. To successfully circle the marine life, the AMS must transit around them until it has crossed its original path, transiting at least 360 degrees. The clockwise/counter-clockwise direction will be based on the classification of the marine life by their spectral signatures (to be developed and distributed to teams separately).

### 5.3.2 Task Elements

Proposed task elements for the Follow the Wildlife Encounter and Avoid task are detailed in Table 5.

**Table 5: Task Elements for Wildlife Encounter and Avoid**

Task Element	Description	Model No.	Ht. Above Waterline	Base Diam.
<b>Marine Life Markers</b>	Horizontal plywood painted with paints with different spectral signatures	N/A		
<b>Field Boundary</b>	470mm Dia. Round Buoy (Orange)	N/A		



## 5.4 Challenge Task 4 - Scan the Code

The Scan the Code task has been a staple of the RobotX Challenge since the inaugural event in 2014.

The AMS is required to observe a light sequence displayed by an RGB buoy and report the color pattern.

The light assembly on the buoy will successively display colors one at a time to generate a sequential pattern of three colors (e.g. red-green-red).

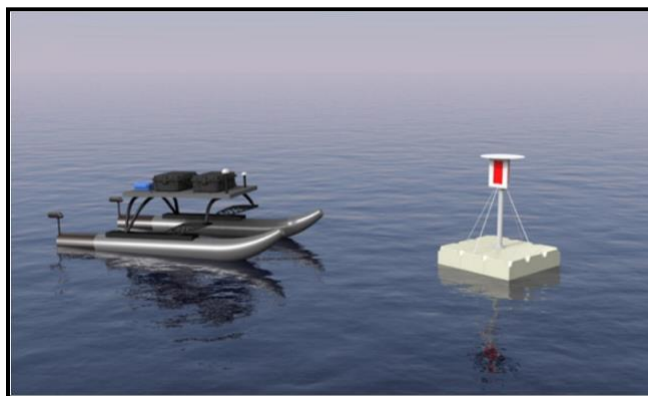


Figure 8: Scan the Code

### 5.4.1 Detailed Task Description

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

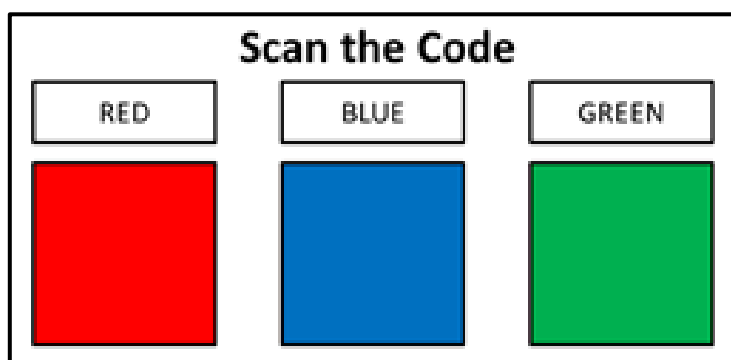


Figure 9: Example Scan the Code Report

### Qualifying Round

During Practice and Qualifying Rounds, teams will report the detected light sequence in real time using a Scan the Code graphical display as detailed in Figure 11. The example Scan the Code report in Figure 10 shows the report of Red, Green, Blue for the light buoy. The Scan the Code report must be available for judges to see in the shore operations area as described in Figure 11.

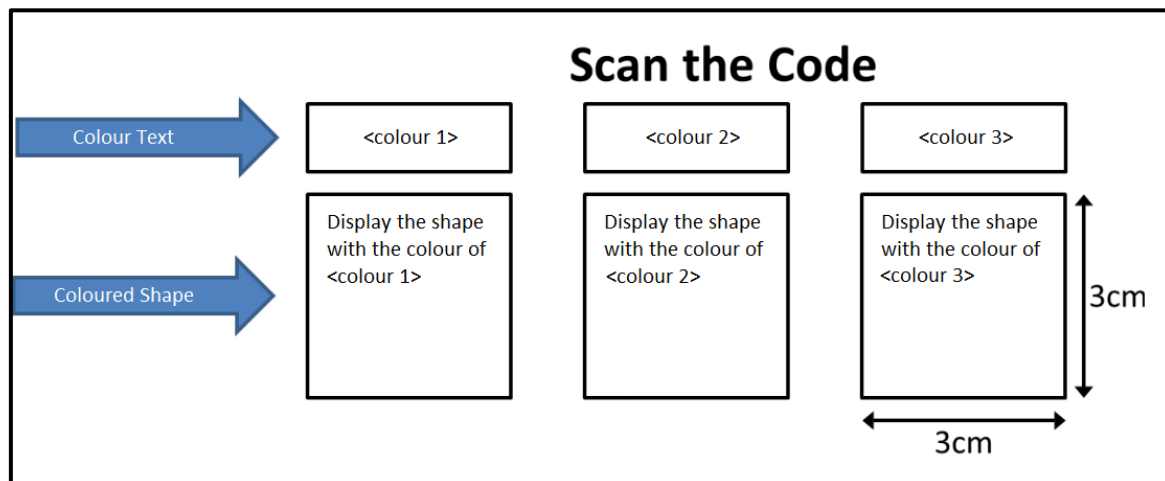


Figure 10: Scan the Code Judge's Display Specifications

### *Semi-final and Final Rounds*

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

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

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

## 5.5 Challenge Task 5 - Dock and Deliver

For the 2022 RobotX Challenge, the docking bays will have a parallel dock configuration (similar to the 2016 RobotX Challenge). This task combines the docking task and the Detect and Delivery task from 2018 RobotX Challenge. The AMS will need to dock in the bay displaying the correct colored light and deliver payloads into one of the two holes.

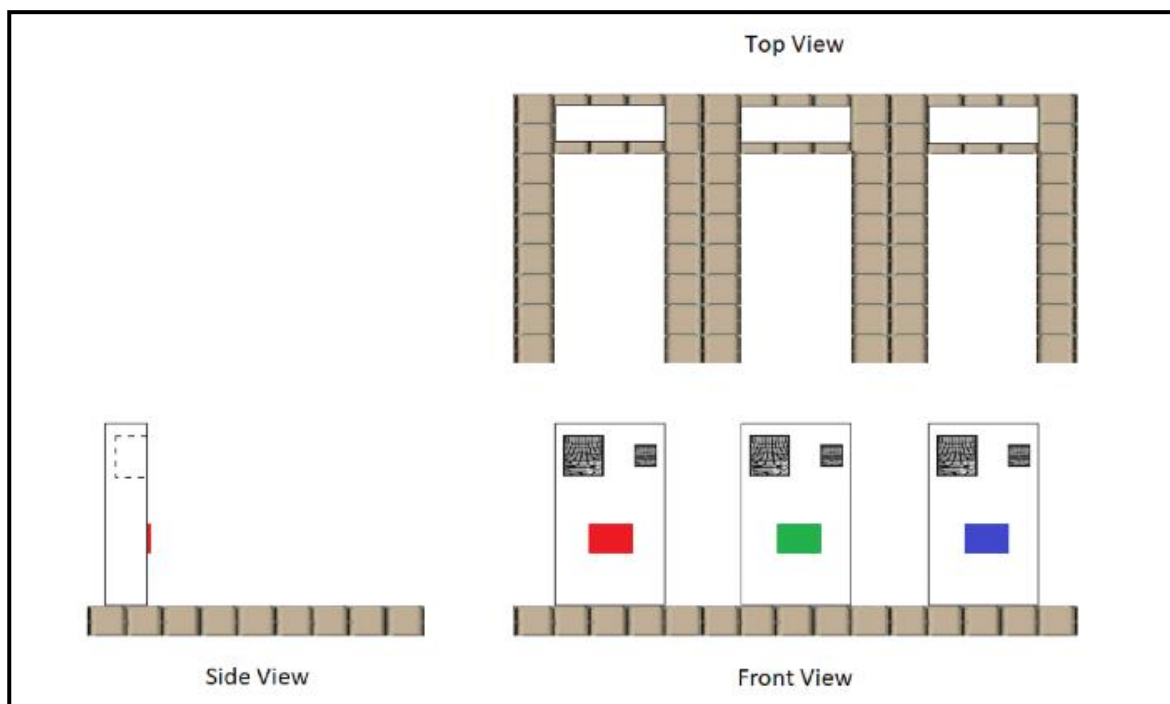


Figure 11: Docking and Delivery Bays

### 5.5.1 Detailed Task Description

The task will consist of three identical docking bays arranged as depicted in Figure 12. The dock will be anchored to a fixed location in the course. On one side of the platform, a colored light or vinyl printed color, and a pair of square target holes, one small and one large, will be visible at the head of each bay. The color may be red, green, or blue in color and will be at least 20cm across. The two holes, one larger than the other, will each be outlined in black on a white background. The larger hole will be a square 0.5m on a side, and the smaller hole will be a square 0.25m on a side.

#### *Qualifying Round*

During practice and qualifying rounds, the Technical Director will designate the colored light of the day (red, green, or blue). The AMS must detect the correct colored light on the docking station and once detected, the AMS must successfully dock in the bay identified by the correct colored light.

Once docked, the AMS will deliver a payload (racquetball) into one of the two holes (located above the colored light). As in previous years, there will be a smaller and larger hole for payload delivery, with the smaller hole worth a greater number of points.

### *Semi-final and Final Rounds*

For the Semi-finals and Finals, the task requirements will be the same as for the qualifying round, however the correct light color will be determined by the first colored light from the Scan the Code task instead of being designated directly by the Technical Director.

#### 5.5.2 Task Elements

Proposed task elements for the Dock and Deliver task are detailed in Table 6.

**Table 6: Task Elements for Dock and Deliver**

<b>Task Element</b>	<b>Description</b>
<b>Blue Projectile</b>	Penn Ultra-Blue Racquetball

## 5.6 Challenge Task 6 – UAV Replenishment

This is a new task for the 2022 RobotX Challenge designed for completion by a UAV. In this task, the UAV must pick up an item from a floating helipad and deliver it to another floating helipad.

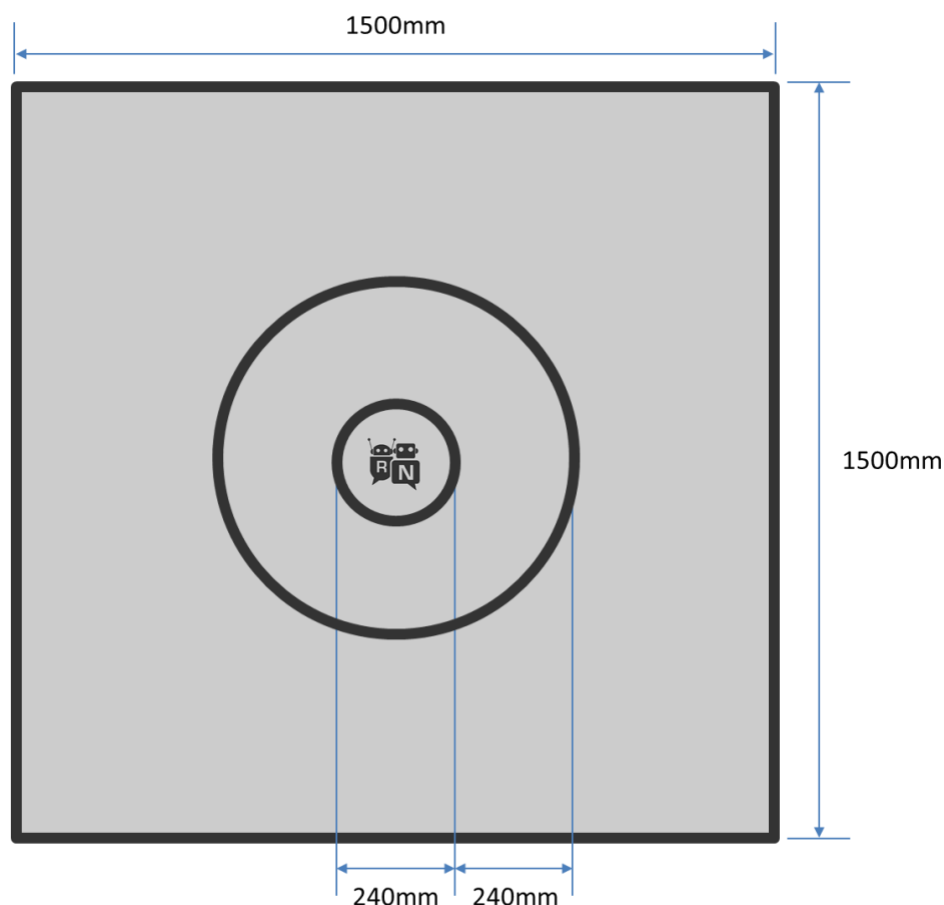


Figure 12: Proposed Helipad

### 5.6.1 Detailed Task Description

For this task, the UAV must launch from the WAM-V, recover a metal disk from one of two floating helipads, and deliver (place not drop) it to the other helipad with the UAV landed. Greater consideration may be given placing the disc closer to the center of the helipad.

Two helipads will be floating within a marked course area in each of the Challenge or Competition Courses. The helipads will be placed on a raised platform approximately 203.2-381 mm above the surface of the water. The helipad will be approximately 1.5m<sup>2</sup> and consist of concentric rings (see Figure 12).

There may be multiple discs on each floating helipad, painted red, green, or blue.

### *Qualifying Round*

During the Practice and Qualifying Round, teams must demonstrate that their UAV can autonomously complete the following mission sequence:

1. Launch from the WAM-V
2. Capture a colored disc from one of the floating helipads
3. Deliver (place not drop) the captured disc to the other floating helipad
4. Safely return to the WAM-V

### *Semi-final and Final Rounds*

For the Semi-finals and Finals, there may be the requirement for the UAV to recognize and move a specific disc color based on input from other tasks, such as Scan the Code and Dock and Deliver.

Specifications for the discs and helipads are shown in Figure 12, Figure 13, and Table 7.

#### 5.6.2 Task Elements

Proposed task elements for the UAV Replenishment task are detailed in Table 7.

**Table 7: Task Elements for UAV Replenishment**

Task Element	Description
<b>Helipad</b>	See Figure 1. Helipad will be secured on a hard, flat, raised surface which will float on the water.
<b>Colored Disks</b>	SimbaLux Screw Top Round Steel Tin Cans 4 oz (120 ml) with Self Adhesive Round Stickers. See Figure 2 Link: <a href="https://www.amazon.com/SimbaLux-Screw-Adhesive-Stickers-24-Pack/dp/B07YBGZ7BN/">https://www.amazon.com/SimbaLux-Screw-Adhesive-Stickers-24-Pack/dp/B07YBGZ7BN/</a>
<b>HSI Camera</b>	An hyperspectral camera will be provided at no cost to registered teams that wish to use the RoboNation-furnished camera to undertake this challenge. The cameras will be available in November 2021 (further camera specifications and details will be provided separately).

## 5.7 Situational Awareness Reporting Task

Situational awareness is an integral component of unmanned systems. Understanding an unmanned system's intent is critical in building operator trust. The 2022 RobotX Communications Protocol (see Appendix C) provides a standardized protocol through which heartbeat and task information must be communicated to judges and Technical Director staff.

Any task described in Appendix C: 2022 RobotX Communications Protocol may be reported using the guidance provided there.

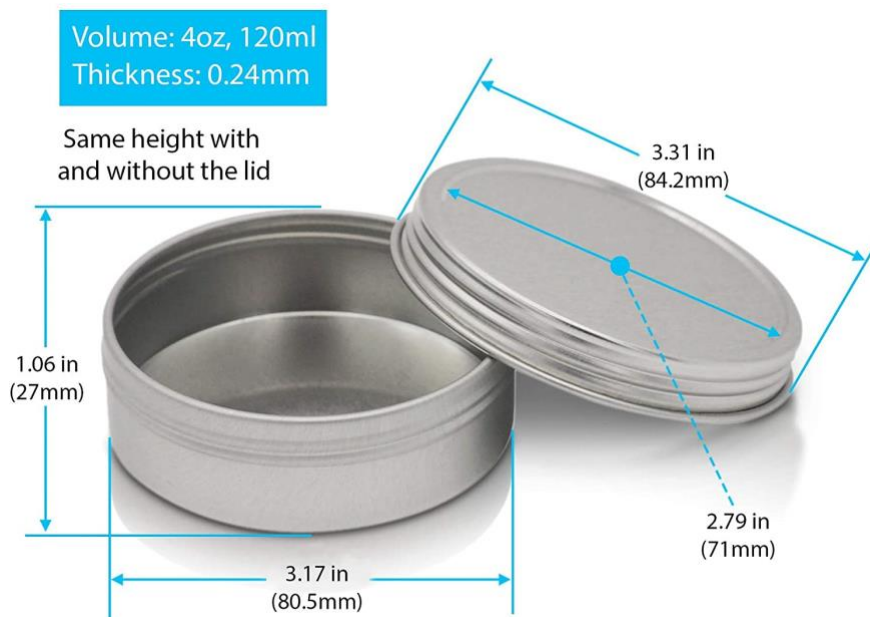


Figure 13: Colored Disk

(top round sticker will be colored red, green, or blue)



## 6. Other Considerations

### 6.1 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 throughout the operating areas in an effort to provide a more representative real-world challenge.

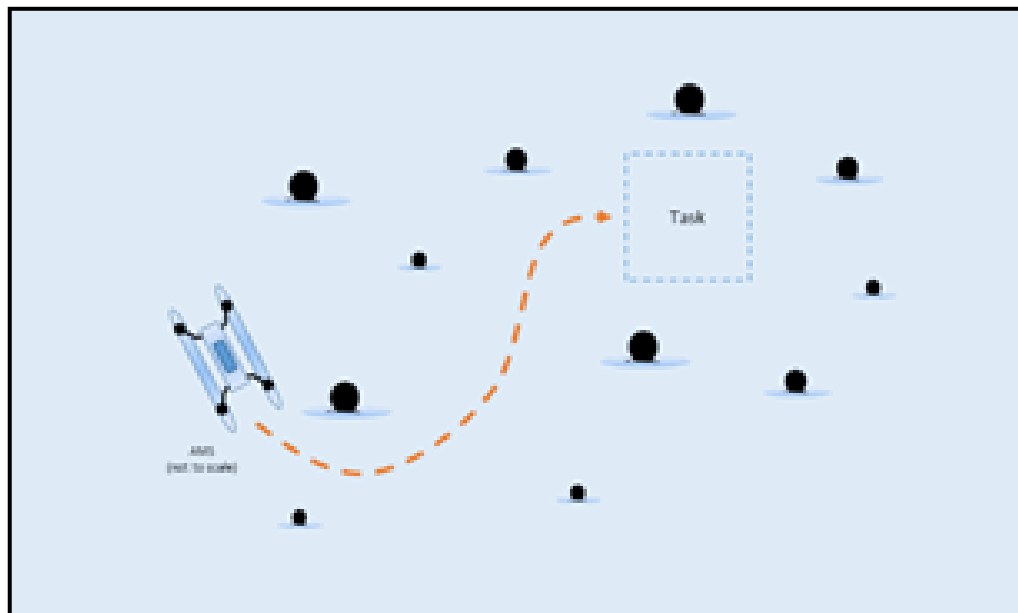


Figure 14: Obstacle Avoidance

### 6.2 Autonomous Maritime System Heartbeat

In previous RobotX Challenges (2016, and 2018) teams were required to implement a visual feedback system and a heartbeat broadcast system. This will continue to be part of the 2022 RobotX Challenge requirements.

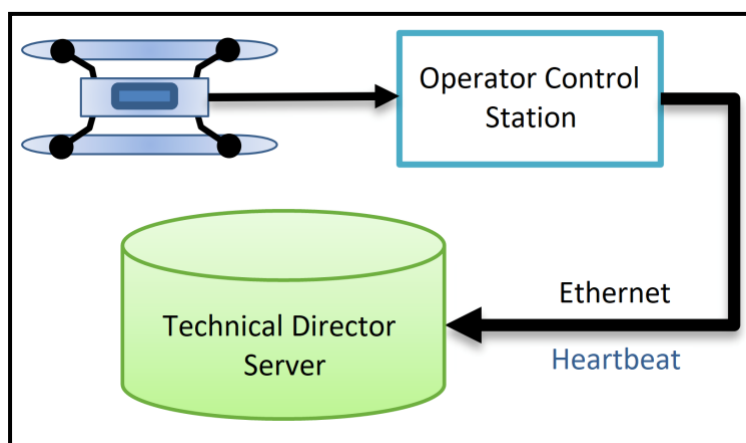


Figure 15: AMS Heartbeat

Teams at each of the course operations tents will be provided with a wired RJ45 connection. Information from the team's Operator Control Station (OCS) will be transmitted to the Technical Director (TD) network, using this wired connection. Teams are expected to provide their own wireless link for information exchange between the AMS and their OCS. Details regarding communications protocol can be found in Appendix C: 2022 RobotX Communications Protocol.

## 7. RobotX Project Deliverables and Presentations

Each team shall design a Website, write a Technical Design Paper, create a Video, conduct an oral presentation, and present their System for inspection. Each team is responsible for ensuring all deadlines are met by the specified dates on the RobotX website.

### 7.1 Technical Submission Package

The Technical Submission Package and Design Presentation Tasks comprise a critical element of the competition.

#### 7.1.1 Technical Design Paper

Each team is 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. They should include the rationale for their design choices. Guidelines will be available on the [RobotX website](#).

#### 7.1.2 Video

Each team is required to submit a video. These videos will be scored and may be shared online and with the RoboNation community. Guidelines will be available on the [RobotX website](#).

#### 7.1.3 Website

Teams must maintain a website documenting their vehicle development. Layout and contents of the website are left for the teams to develop; however, the website will be scored and should include at a minimum the following information:

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

Team websites developed for a previous competition should be updated to reflect RobotX 2022 team information and vehicle design. Guidelines will be available on the [RobotX website](#).

### 7.2 Information Package

Teams are required to submit a team roster, liability waivers, forms, and other information.

### 7.3 Shipping Plan

Teams will be required to submit a shipping plan to RobotX organizers. This is to allow time for organizers to work with teams to ensure that their systems and support equipment can be received, worked through **Australian Customs**, and staged for use during the competition. A shipping plan form, shipping address, and point of contact for the RobotX freight forwarder will be provided directly to teams.

## 7.4 Design Documentation Presentation

Each team is required to present their sensing, integration, power, propulsion, and autonomy schemes for both the USV and UAV to the judges in the form of an oral presentation (conducted in English) with visual aids.

### 7.4.1 System Inspection

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

## 8. Important Terms

Table 8: Important Terms

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

## 9. Change Log

Table 9: Change Log

Version	Changes	Date
<b>v1.0</b>	First release of Preliminary Task Descriptions, based on "Task Ideas" document from 03 February 2021.	<b>XXXX</b>

## Appendix A: Beacon Specifications

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

### *Beacon Model*

The beacon selected for use during the RobotX competition is the Benthos ALP-365. This model has a selectable frequency between 25 and 40kHz with a 0.5kHz increment. It also has multiple options for repetition rate.

A link to the specifications: [robotx.org/benthos-locator](https://robotx.org/benthos-locator)

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

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



**Figure 16: Benthos ALP-365 Beacon**

## Appendix B: Light Buoy Specifications

### B.1. Network Information

#### *Description*

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

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

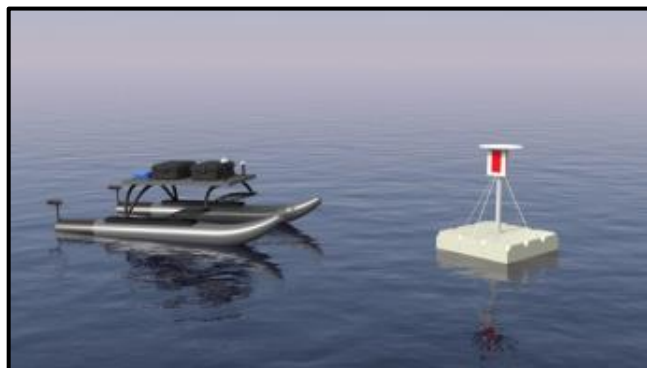


Figure 17. Light Buoy Concept

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

#### *Specifications*

The dimensions of one of the three identical faces are shown in Figure 18. The top edge of these faces will be between 3 meters (9.8 feet) and 1 meter (3.2 feet) above the water. The border around the LED panel will be white, as illustrated. The structure supporting these faces is subject to change and is not specified here.

#### *Parts Source*

The LED panels to be used for the competition buoy panels were purchased at the following link:

<http://www.adafruit.com/products/420>

Software that Teams may use to program and test a representative light panel is available at GitHub:

<https://github.com/madsci1016/RobotXLightBuoy>

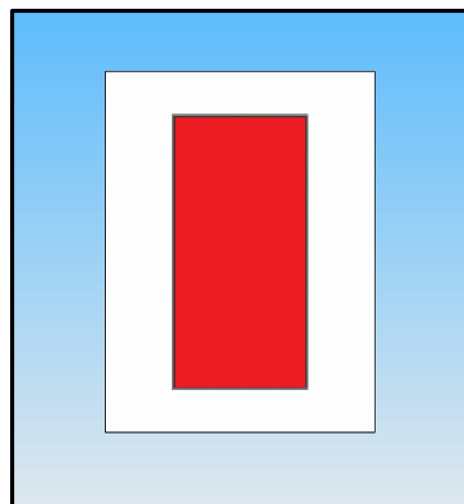


Figure 18. Light Buoy Face

## Appendix C: 2022 RobotX Communications Protocol

This appendix describes the communications protocols to be used during the 2022 Maritime RobotX Challenge for the purpose of reporting vehicle status and completion of mission tasks. Each team's implementation of the requirements, outlined below, may be tested during the Challenge. RoboNation shall provide support to test this implementation prior to the RobotX Challenge.

### C.1. Network Information

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

When connected to the 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 will be formatted as a NMEA-like sentence characterized by the following guidelines:

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

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

### C.3. Heartbeat Message

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

**Table 10. RobotX 2022 Heartbeat Message Fields**

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>	AUVSI	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	<ul style="list-style-type: none"> <li>The 'Stowed' state used only when the UAV is secured to the WAM-V.</li> <li>The 'Deployed' state is used whenever the UAV is not on board the WAM-V.</li> <li>The 'Faulted' state is used whenever the UAV is not functioning as designed.</li> </ul>
<b>Checksum</b>	0D	Bitwise XOR	
<b>&lt;CR&gt;&lt;LF&gt;</b>		End of message	

Heartbeat Example Message:

\$RXHRB,111221,161229,21.31198,N,157.88972,W,AUVSI,2,1\*0D



## C.4. Entrance and Exit Gates

The Entrance and Exit Gates message provides a method for the AMS to report the gate in which it detects an active beacon using the protocol specified in Table 11. An example is provided below the table. When the AMS transmits this message the Technical Director system will echo received message back to verify transmission.

**Table 11. Entrance and Exit Gate Message Fields**

Name	Example	Description
Message ID	\$RXGAT	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	AUVSI	Team ID (assigned by Technical Director)
Active Entrance Gate	1	Gate 1, 2, or 3
Active Exit Gate	2	Gate 1, 2, or 3
Checksum	20	Bitwise XOR
<CR><LF>		End of message

Entrance and Exit Gate Example Message:      \$RXGAT,111221,161229,AUVSI,1,2\*20

## C.5. Follow the Path

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 12. An example is provided below the table. When the AMS transmits this message the Technical Director system will echo received message back to verify transmission.

**Table 12. Follow the Path Message Fields**

Name	Example	Description
Message ID	\$RXPTH	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	AUVSI	Team ID (assigned by Technical Director)
Finished	1	1 = In Progress 2 = Completed
Checksum	20	Bitwise XOR
<CR><LF>		End of message

Follow the Path Example Message:      \$RXPTH,111221,161229,AUVSI,1\*20

## C.6. Wildlife Encounter and Avoid

The Wildlife Encounter and Avoid task requires that the AMS identify and classify 'wildlife' objects with a UAV and circle or avoid 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 13. An example is provided below the table. When the AMS transmits this message the Technical Director system will echo received message back to verify transmission.

**Table 13. Wildlife Encounter and Avoid Message Fields**

Name	Example	Description
<b>Message ID</b>	RXENC	Protocol Header
<b>AEDT date</b>	111221	ddmmyy
<b>AEDT time</b>	161229	hhmmss
<b>Team ID</b>	AUVSI	Team ID (assigned by TD)
<b>Num Detected</b>	3	1, 2 or 3 'wildlife' objects detected
<b>1<sup>st</sup> Wildlife</b>	P	Classification of 1 <sup>st</sup> Wildlife Object P=Platypus, C=Crocodile, T=Turtle
<b>2<sup>nd</sup> Wildlife</b>	C	Classification of 2 <sup>nd</sup> Wildlife Object P=Platypus, C=Crocodile, T=Turtle
<b>3<sup>rd</sup> Wildlife</b>	T	Classification of 3 <sup>rd</sup> Wildlife Object P=Platypus, C=Crocodile, T=Turtle
<b>Checksum</b>	4D	Bitwise XOR
<CR><LF>		End of message

Wildlife Encounter Example Message:

\$RXENC,111221,161229,AUVSI,3,P,C,T\*4D

## C.7. Scan the Code Message

The Scan the Code task requires that the AMS locate and observe a buoy with a light bar to determine the light pattern displayed. The AMS must then transmit the detected light pattern using the protocol specified in Table 14. An example is provided below the table. When the AMS transmits this message the TD system will echo received message back to verify transmission.

**Table 14. Scan the Code Message Fields**

Name	Example	Description
<b>Message ID</b>	\$RXCOD	Protocol Header
<b>AEDT date</b>	111221	ddmmyy
<b>AEDT time</b>	161229	hhmmss
<b>Team ID</b>	AUVSI	Team ID (assigned by Technical Director)
<b>Light Pattern</b>	RBG	Colors identified from first to last, over time R=red, B=blue, G=green
<b>Checksum</b>	42	Bitwise XOR
<CR><LF>		End of message

Scan the Code Message Example:

\$RXCOD,111221,161229,AUVSI,RGB\*42

## C.8. Dock and Deliver Message

The Dock and Deliver task requires that the AMS identify an assigned colored light and deliver a payload into one of the holes. The AMS may report the detected color of the face where it will deliver its payload using the protocol specified in Table 15. An example is provided below the table. When the AMS transmits this message the Technical Director system will echo received message back to verify transmission.

**Table 15. Dock and Deliver Message Fields**

Name	Example	Description
Message ID	\$RXDOK	Protocol Header
AEDT date	111221	ddmmyy
AEDT time	161229	hhmmss
Team ID	AUVSI	Team ID (assigned by Technical Director)
Light Color	R	Colour of the shape on the face being targeted R=red, B=blue, G=green
AMS Status	1	Status of the AMS 1=Docking, 2=Delivering
Checksum	52	Bitwise XOR
<CR><LF>		End of message

Dock and Deliver Example Message: \$RXDOK,111221,161229,AUVSI,R,1\*52

## C.9. UAV Replenishment

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 has deployed, picked up the item and delivered the item using the protocol specified in Table 16. An example is provided below the table. When the AMS transmits this message the Technical Director system will echo received message back to verify transmission.

**Table 16. UAV Replenishment Message Fields**

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>	AUVSI	Team ID (assigned by TD)
<b>UAV Status</b>	Current status of the UAV 1=Stowed 2=Deployed 3=Faulted	<ul style="list-style-type: none"> <li>The 'Stowed' state is used only when the UAV is secured to the WAM-V.</li> <li>The 'Deployed' state is used whenever the UAV is not on board the WAM-V.</li> <li>The 'Faulted' state is used whenever the UAV is not functioning as designed.</li> </ul>
<b>Item Status</b>	Current status of item 0=Not Picked Up 1=Picked Up 2=Delivered	<ul style="list-style-type: none"> <li>The 'Not Picked Up' state is used when the item has not been picked up by the UAV</li> <li>The 'Picked Up' state is used once the item has been successfully picked up by the UAV</li> <li>The 'Delivered' state is used when the item has been successfully delivered by the UAV</li> </ul>
<b>Checksum</b>	30	Bitwise XOR
<CR><LF>		End of message

UAV Replenishment Example Message:      \$RXUAV,111221,161229,AUVSI,2,1\*30