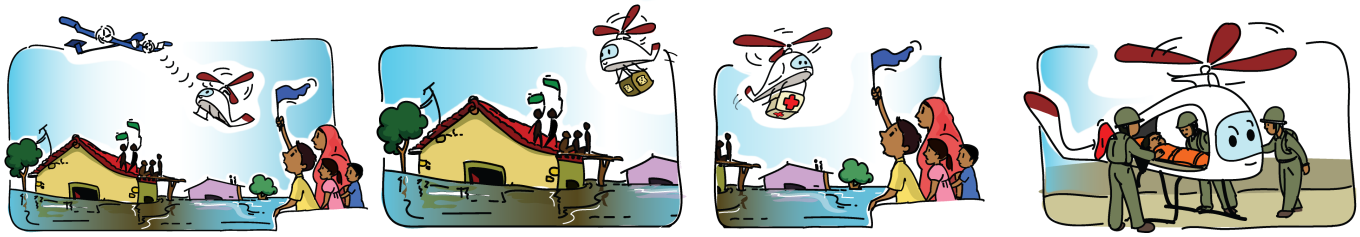

RULE BOOK

# SURVEY AND RESCUE

e-Yantra Team

December 10, 2019

# 1 Introduction

For millennia, humans have been using land and water to navigate terrain. Air travel has revolutionized many facets of our lives, one amongst which is identifying and providing relief or rescuing fellow humans and their property when their safety is threatened in disasters.

Advances in materials and electronics have led to a boom in portable aerial robots. These can be either user operated or autonomous, with major research going on in enhancing their autonomous capabilities. These robots, called Unmanned Aerial Vehicles (UAVs) can be classified as multirotor, tiltrotors, helicopters, fixed-wing etc.

Quadcopters, a variety of multirotor aircraft are the most ubiquitous amongst these, and in the recent Western India floods of 2019, they have been used with great success, by hobbyists, professional photographers and others to survey and assess the damage to life and property, and helping to coordinate search and rescue operations. Their inspiring actions and stories can be found on the internet. So, what could be a step-up to these systems? At present, they are limited in range, size and payload. Autonomous light helicopters of course! Manned-light helicopters are widely used in rescue situations, making them autonomous and ubiquitous will surely be a concrete step forward in this regard.

In eYRC 2019-20 we explore an abstracted version of this disaster scenario, using a micro-quadcopter which operates autonomously to perform search and rescue operations. In the process you will learn concepts in control systems, image processing and algorithm development. We have split the competition into a series of Tasks which will help you accomplish the above goal of solving the problem using an autonomous quadcopter. We'll ride along with you in the journey, but it is yours' to undertake. The team that performs all the tasks fastest whilst incurring minimum penalties as per rules will be declared the winner.

ALL THE BEST!

**Key words:** Quadcopter, Drone, Control Systems, Image Processing, Scheduling, Robot Operating System

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# 2 Theme Description

## 2.1 Terms

1. **Rescue Drone(RD):** This is the drone which navigates in the arena. It has a **WhyCon marker** attached for localization.
2. **The Arena** is a hypothetical representation of a flooded region, as shown in Figure 2.1. The arena is divided into 6x6 Cells. Rows are referenced using numerals from 1 through 6 and columns are referenced using letters A through F. An intersection cell on the grid would be referenced as A1, C3, and so on.

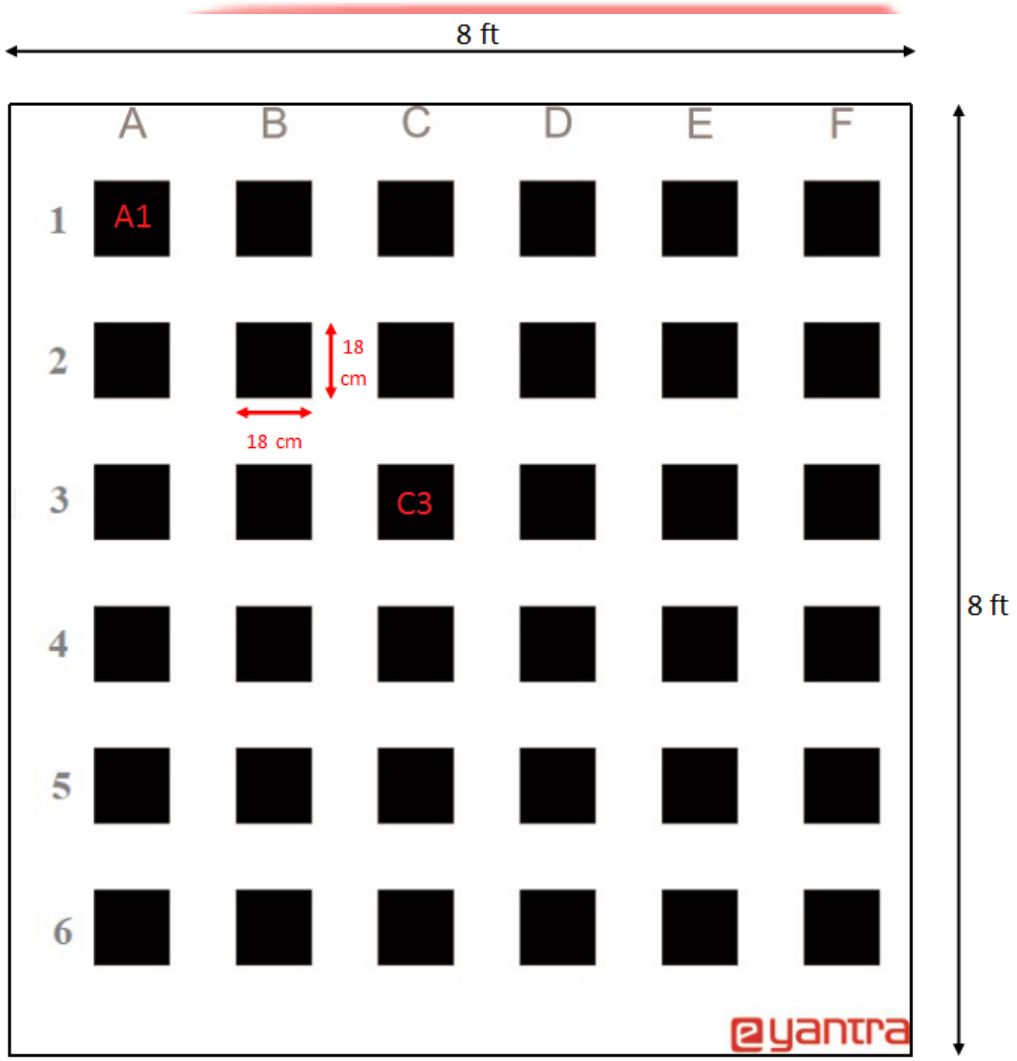


Figure 2.1: Arena with Cell Notations Displayed

3. **LED Modules** are the addressable LED modules placed at various cells in the arena. Their placement will be given in a configuration table like 2.1.

4. **Beacons** are indicators placed by people in distress or in need of immediate rescue. Beacons are of three types represented by three different colors attained by the LED modules.
   (a) **MEDICINE:** This Beacon represents a requirement for medicine; it is indicated by the LED module lighting up as blue.
   (b) **FOOD:** This Beacon represents a requirement for food; it is indicated by the LED module lighting up as green.
   (c) **RESCUE:** This Beacon represents a requirement for an urgent medevac (airlift rescue); it is indicated by the LED module lighting up as red.
   (d) The Beacons will appear in a pseudo-random manner during the run. Rules for servicing these requests are mentioned in the Theme Rules section.
5. **The Base Station** Station is the cell where the Rescue Drone can be reloaded with food and medical supplies since it has a limited payload capacity. In case of a RESCUE mission, the Rescue Drone needs to come back to the Base Station immediately for successfully completing mission. The location of the Base Station will be provided at the start of the run.

## 2.2 Inputs

The configuration table is provided at the start of a run, a sample configuration is provided below. Refer Figure 3.4 for the configuration according to the Table 2.1.

| LED Module Number | Location |
|---|---|
| 1 | B6 |
| 2 | A4 |
| 3 | C2 |
| 4 | E3 |
| 5 | F2 |
| 6 | E5 |
| 7 | D6 |
| 8 | B6 |
| Base Station | B2 |

Table 2.1: Configuration Table

# 3 Arena

Each team has to prepare the arena. Preparing the arena consists of:

1. Printing the Arena on the Flex Sheet
2. Preparing LED Modules
3. WhyCon Marker Construction
4. Setting up the Overhead Camera
5. Orienting Arena with respect to the Camera Frame

**NOTE: Teams are not allowed to make any changes in the arena design. Any team making unauthorized modifications will be disqualified from the competition.**

## 3.1 Printing the Arena on the Flex Sheet

The Arena design to be printed on a flex sheet is as shown in Figure 2.1. A pdf file containing the arena design will be provided to the teams. Each team prints the flex design according to the instructions given along with the pdf file in Task 2.

**WARNING: Please be careful while handling the flex sheet – avoid folding it like a bed-sheet since the resultant folds will cause problems while the robot moves. One way of "flattening" flex if it has been compromised is to hang it for a few hours in the sun – it tends to straighten out. Never attempt ironing it or applying heat of any kind – it may be a fire hazard.**

Dimensions of the arena are as shown in the Figure 2.1:

- Dimension of the flex sheet is $8ft \times 8ft$.
- Dimension of each cell is $18cm \times 18cm$.

## 3.2 Preparing LED Modules

- Beacons are represented by LED modules.
- Each LED module consists of 4 LEDs connected in series.
- You are not permitted to use any other number of LEDs per module.
- Each module has two wires for connecting with other LED modules.
- 8 such modules will form a chain.
- The 1st LED module will connect to the Y cable which connects the LED chain to Arduino and power supply.
- Prepare the LED modules as per Figure 3.1.
- Follow the instructions in this video for construction of the LED Modules.

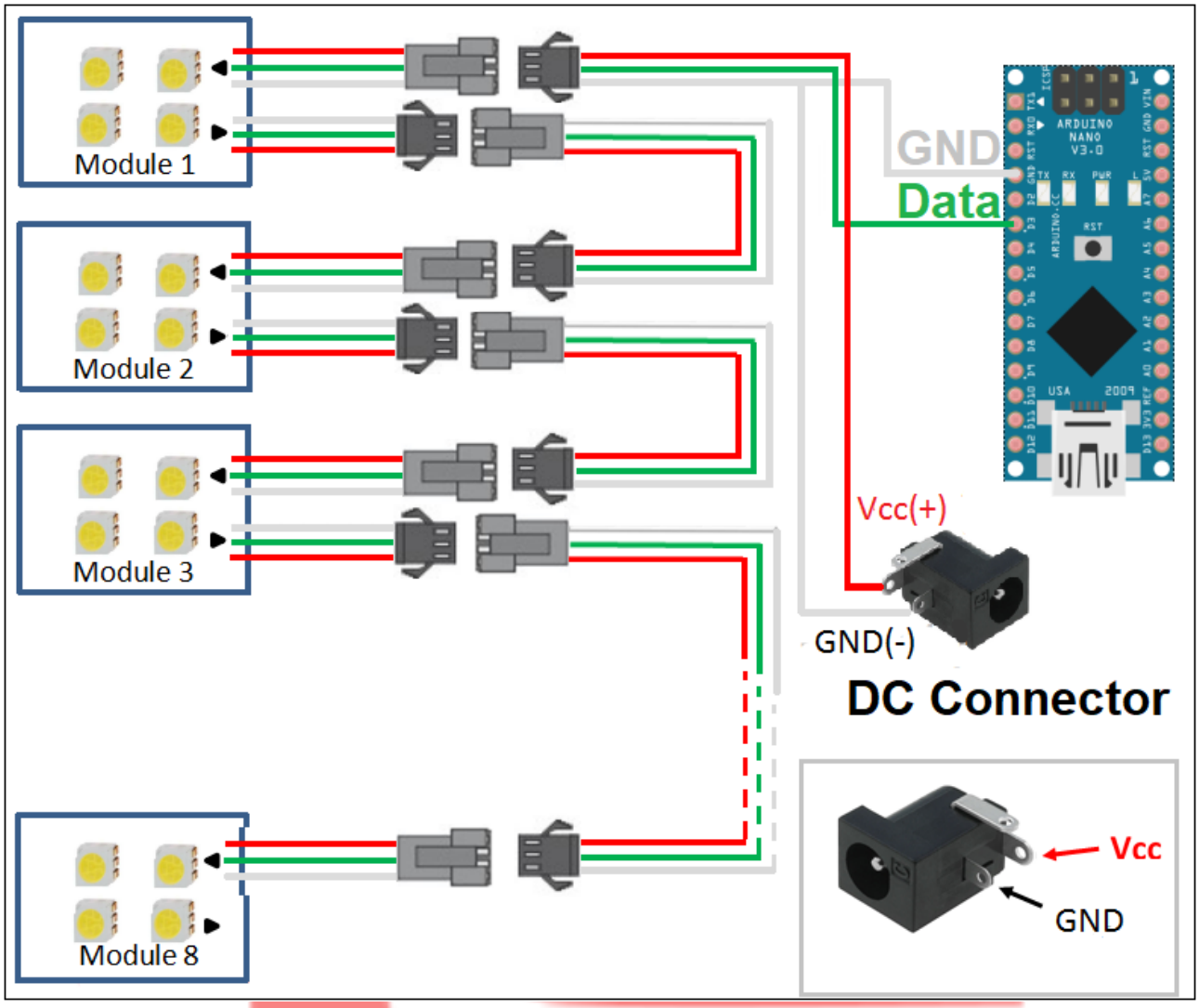


Figure 3.1: Wiring Diagram for LED Modules

## 3.3 WhyCon Marker Construction

- You will find a printed A4 sheet of WhyCon markers in the package which has been shipped to you.
- Alternatively, you can download it here.
- You have to attach the WhyCon marker to the top of your Drone, so that it can be tracked by the overhead camera.
- You may refer to this video for suggestions on how to do so.

## 3.4 Setting up the Overhead Camera

- You have been provided with a camera and it's USB extension cable.
- The provided camera must be mounted such that it has a complete view of the arena.
- Camera should be mounted above the center of the arena at a height of 8-10 feet.
- Make sure that you fix the camera parallel to the ground and not in an inclined manner.
- Teams are expected to use their creativity to design an arrangement to mount the camera, for example, hang it from the ceiling, construct a frame etc.
- The extension cable will be used to connect the camera to the PC/Laptop.
- Figure 3.2 shows an example setup for the overhead camera.

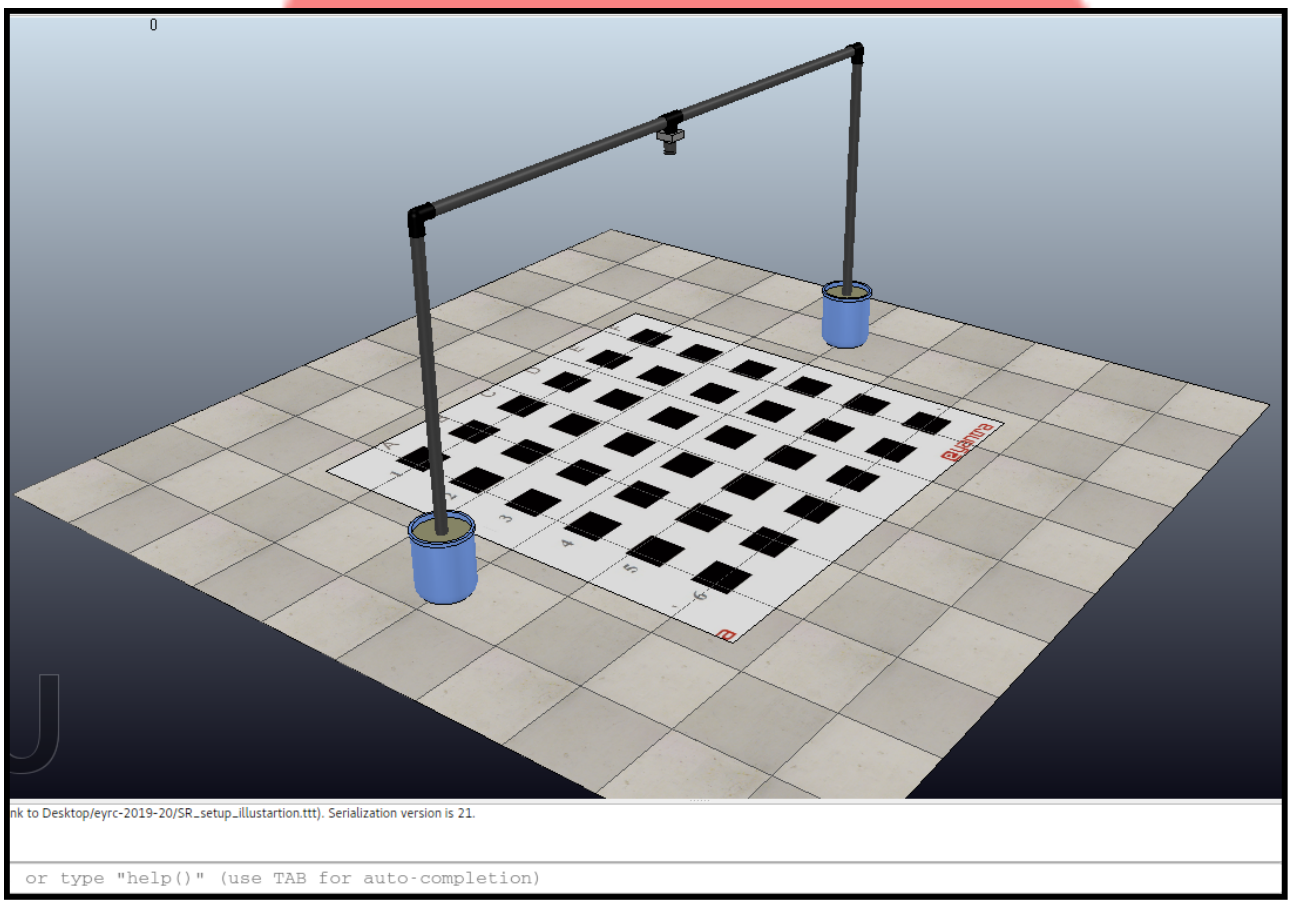


Figure 3.2: Sample Overhead Camera Setup

### 3.5 Orienting Arena with respect to the Camera Frame

- Set the flex on the floor such that the entire flex appears in the overhead camera frame and the e-Yantra logo appears at the bottom left corner.
- Try to fix the flex position and orientation so that the output of WhyCon coordinates remain constant.
- A sample image of the overhead camera fame which shows flex along with a WhyCon marker is shown in Figure 3.3.
- Following this the WhyCon coordinates of the Cells need to be pre-mapped and saved for all future reference. This will be achieved by running a pre-made script.

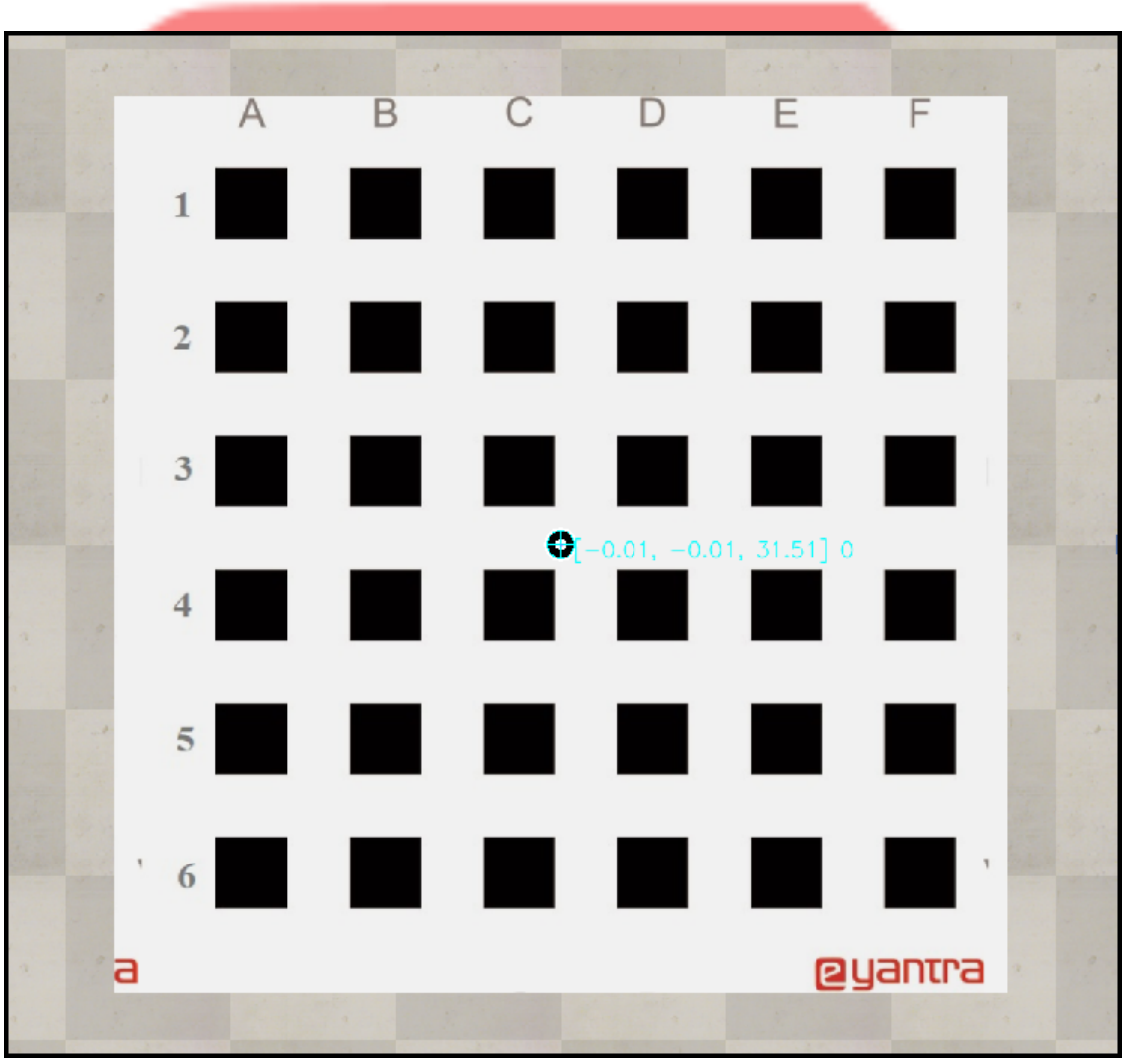


Figure 3.3: WhyCon Image Output

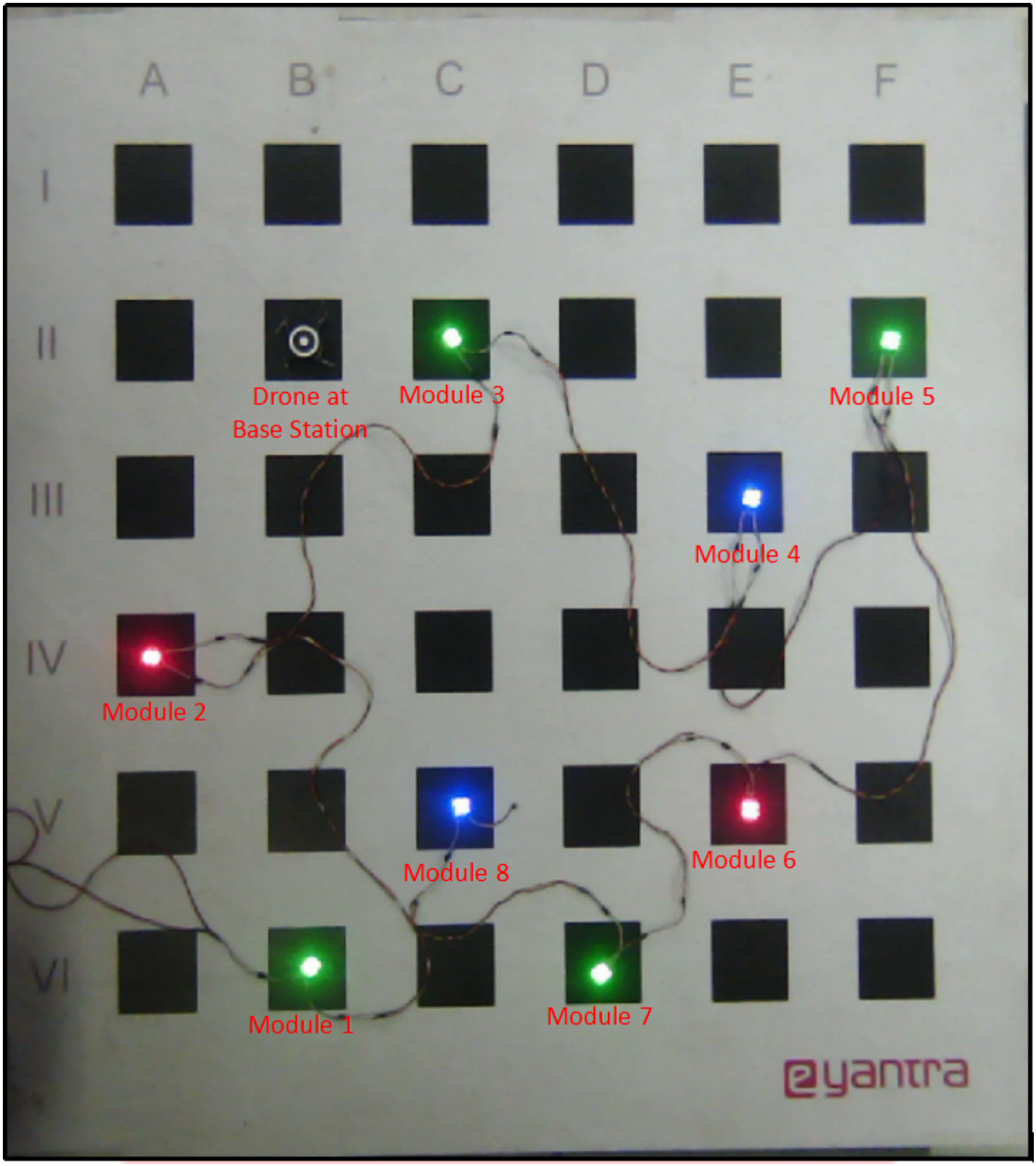


Figure 3.4: Sample Arena Configuration

# 4 Hardware Specifications

- All the participating teams must use only the components which were sent to them in the kit.
- The Rescue Drone should be completely autonomous. The team is not allowed to use any wireless remote for its manual control.
- Teams are allowed to create any type of mechanical mount for mounting camera above the arena.

**Note:** No other expansion and/or micro-controller based boards shall be attached to the Rescue Drone.

# 5 Software Specifications

- The teams must use Python to write their code.
- As per e-Yantra policy, all your code and documents are open-source and may be published on the e-Yantra website.

# 6 Theme Flow

- The arena is setup to generate Beacon Events in a pseudo-random fashion.
- The Rescue Drone is armed at the Base station.
- The Beacon detector script starts at the same time.
- The Beacon detector script notifies the system of a new detection by publishing an appropriate ROS message.
- The decision-making script, decides which Beacon to service out of a pool of the received notifications from the Beacon detector script.
- The Rescue Drone services this Beacon as per the rules mentioned in the Theme Rules section.
- This goes on for the period of the run (deployment).
- Please refer to the Theme Rules section for further details.

# 7 Theme Rules

## 7.1 Rules

1. A run (deployment) will be of a period of 3 minutes, during which pseudo-random *Events* will be generated at the Beacon locations as per the Event Specifications subsection.
2. The team should detect these Events using the overhead camera, while following the rules listed in the Detection Rules subsection.
3. The team should decide which of these Events to Service, while following the rules listed in the Decision Rules subsection.
4. The Rescue Drone must service these detected events, while following the rules listed in the Servicing Rules subsection.
5. The Team must detect the position of the Rescue Drone using the overhead camera.
6. The Rescue Drone has a fixed capacity of 3 Food packages and 3 Medicine Packages. Which it can replenish by hovering over the Base Station for 5 seconds.
7. Each service decreases this capacity by 1.

## 7.2 Event Specifications

1. An *Event* is defined as an indication by a *Beacon* requesting a certain *Service*.
2. Any number of Events could be generated in a run subject to the following requirements.
   (a) The Food and Medicine Events, once indicated will be active for a period of 30s, after which the Beacon may either turn off or change Service requests (fire a different Event) and it will no longer be available to be Serviced.
   (b) The Rescue Event, once indicated will be active for a period of 10s, after which the Beacon will turn off or change Service requests (fire a different Event) and it will no longer be available to be Serviced.
   (c) A service failed message will be published automatically for the location of the Beacon and the Beacon will turn off in both of these eventualities.
   (d) The Servicing Rules subsections covers the criteria for successful services.

## 7.3 Detection Rules

1. Detection of an Event should be carried out by the image processing script and should be published only once, for e.g. if a Food Beacon is fired at C5, then you should publish the message only once and not continuously.

## 7.4 Decision Rules

1. The Team should indicate their Service decision by publishing over the /decision_info ROS topic.
2. The Event can only be successfully Serviced if the Team's current decision is location of that Event. This applies to visiting the Base Station as well.

## 7.5 Servicing Rules

1. An Event has to be Serviced by the Rescue Drone by hovering at a height of $1\frac{1}{2}$feet from the ground.
2. In case of Food and Medicine Events, the Rescue Drone has to hover continuously over the event for a period of 3 seconds before the timeout in order for the event to be considered as serviced.
3. In case of Rescue events, the Rescue Drone has to hover continuously over the event for a period of 5 seconds before the timeout in order for the event to be considered as serviced.
4. if the timeout occurs before the drone has hovered for the stipulated periods, the Event will still time-out and a Service failed message will be sent.
5. The Rescue Drone has to compulsorily return to base i.e. hover over it for 5 seconds, after successfully hovering over a Rescue Event. This indicates carrying the patient to the base.

## 7.6 Reposition Rules

1. Teams are allowed repositions only in the case of their Rescue Drone going out of the arena.
2. It can be started again from the Base. However, the detection and decision scripts, the total run timer and Events will not be stopped.
3. Repositions carry no explicit penalty.

# 8 Judging and Scoring System

The team's total score is calculated by the following formula:

Total Score = (FD*$w_{FD}$)+(MD*$w_{MD}$)+(R*$w_R$)+(CD*$w_{CD}$)-(ID*$w_{ID}$)-(RD*$w_{RD}$)-(IS*$w_{IS}$)

where,

- **FD** is the number of successful food distributions.
  - A successful food distribution is awarded when the Rescue Drone successfully hovers over the FOOD Beacon as per the Servicing Rules subsection.
- **MD** is the number of successful medicine distributions.
  - A successful medicine distribution is awarded when the Rescue Drone successfully hovers over the MEDICINE Beacon as per the Servicing Rules subsection.
- **R** is number of successful rescue missions.
  - A successful rescue mission is awarded when the Rescue Drone successfully hovers over the RESCUE Beacon as per the Servicing Rules subsection.
- **CD** is number of correct Beacon detections.
  - Correct detection is said when a Beacon color is detected correctly and published only once.
- **ID** is the number of incorrect Beacon detections.
  - For example, a RESCUE Beacon is fired and the team detects it as a FOOD or MEDICINE then is said to be an incorrect detection.
  - Also, if there is no Beacon fired in a cell but the team detects it as a service to be provided then it is an incorrect detection.
- **RD** is the number of redundant detections.
  - If a team detects a Beacon and publishes multiple times, then it is said to be a redundant detection.
- **IS** is the number of incorrect services
  - If a team detects an incorrect Beacon in a cell and serves it, it is said to be an incorrect service.
  - For example, if there is a Medicine Beacon Event fired in a cell and the team detects it as a Food Beacon and continues to Service that location as Food, it will be counted as an incorrect service.
- Terms starting with a $w$ and followed by a subscript are weights of each terms, they are enumerated in Table 8.1 below:

| Weights | Values |
|---|---|
| $w_{FD}$ | 10 |
| $w_{MD}$ | 10 |
| $w_R$ | 50 |
| $w_{CD}$ | 5 |
| $w_{ID}$ | 5 |
| $w_{RD}$ | 5 |
| $w_{IS}$ | 10 |

Table 8.1: Weights Table

# 9 Important Notes

- **After completion of all tasks, teams will be selected as finalists based on their cumulative scores across all the tasks. Complete rules and instructions for the finals at IIT Bombay will be sent to those teams that qualify for the finals.**
- **In case of any disputes/ discrepancies, e-Yantra's decision is final and binding. e-Yantra reserves the rights to change any or all of the above rules as we deem fit. Any change in rules will be highlighted on the website and notified to the participating teams.**

ALL THE BEST!