



## IEEE Region 10 Robotics Competition 2022

*Theme: Robotics for Healthcare*



Robotics for Healthcare

### **Hospital Service Robot to Mitigate Infectivity Risks of COVID-19 Pandemic**

#### **Competition Project# 2**

#### **For Undergraduates students**

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# IEEE Region 10 Robotics Competition 2022

## Project 2: for Undergraduates Students

### Hospital Service Robot to Mitigate Infectivity Risks of COVID-19 Pandemic

#### 1. Introduction

Doctors, healthcare staff, and patients in hospital settings are vulnerable to highly transmissible pathogens like the COVID-19 virus. Using robots for many tasks can reduce the risk of virus spreading. For example, one typical task is the delivery of food trays to patients. Therefore, this competition encompasses the development of an autonomous robot to pick an object that represents 'Food Tray' from the 'Pick Up Zone' and place them in the 'Delivery Area' to mimic the act of food delivery to patients in their rooms.

The competition aims to create awareness amongst undergraduate students about the importance of technology in providing solutions to real-world problems by harnessing their creativity and capabilities.

The main objectives of the competition are:

- Create opportunities for learning by applying classroom lessons and enabling methodologies to design a robot,
- Stimulate thought process for innovative ideas, and
- Develop students' abilities to:
  - Study and understand the problem;
  - Analyze and decompose requirements;
  - Conduct literature review and essential background research;
  - Investigate innovative solutions and systematically implement in hardware;
  - Avoid copyright and intellectual property rights violations;

In addition to stimulating technical ingenuity, the competition also aims to help participants to:

- Build teamwork spirits – Learn to optimize team members' abilities to achieve project goals;
- Develop leadership skills – (a) Ability to clearly set goals and effectively communicate plans and strategies to the team members, (b) ability to listen to alternate views and make timely decisions;
- Develop project management skills – Participants are required to apply project management principles to (a) identify project goals, (b) prepare a work breakdown structure (WBS) with realistic timelines, (c) determine key milestones leading to the completion of the project, (d) manage time and resources;
- Sound Engineering Practice – Documentation and recording keeping for (a) robot design features requirements, (b) design decisions, i.e., different options contemplated and the reasons for selected options, (c) ability to trace back the technical errors if any and troubleshooting, (d) foundation for future developments, and (d) proof of originality and ownership of the work;

## 2. Eligibility Criteria

Project# 2 of the R10 Robotics Competition 2022 is open to all IEEE Student members enrolled for a Bachelor's degree in electrical engineering, electronics, computer science, or any other field of interest of an IEEE Society. Anyone who joins the IEEE as a student member after the start of the R10 Robotics Competition will not be accepted as an IEEE member for the competition in 2022.

All contestants in the competition must belong to one of the IEEE Sections in Region 10. Contestant(s) can be an individual or a team as explained below:

- Individual (must be an active IEEE student member)
- Team-based. The number of team members is limited to a maximum of 6 members for this project. Majority of team members must be IEEE student members. For example, in a 3 or 4-member team a maximum of one non-IEEE member can be in the team. The team can NOT have an equal number of IEEE members and non-members.
- Teams must not include any PG student, Young Professional or IEEE member, or higher grade member. However, a senior volunteer in the Section or from the industry can act as an advisor for the team. An advisor must not carry out the tasks related to building the robot or coding the algorithms. It is not necessary for the Advisor to be an IEEE member.
- Teams must not include any UG students from outside the Region 10.
- To qualify as a WIE team, the majority of team members must be female IEEE members and not just the majority of female members. The team can NOT have an equal or more number of males than female members.
- Non-IEEE members in the team will not be eligible for a cash prize. However, they can receive a certificate of participation.

## 3. Competition Outline

This competition will be held in three stages.

**Stage 1** will be held locally by the IEEE Sections with an overall guideline from R10. The top two teams from the Section will be selected to compete in Stage 2. R10 will issue general guidelines for judging the teams. However, Sections will be allowed to use their selection process and criteria to nominate team(s) to represent the Section at Stage 2.

**Stage 2** will be held online and organized by R10. For Stage 2, the competing team will build the prototype Hospital Service Robot. In addition, each team will submit a video presentation of their built robot to demonstrate its functionality.

**Stage 3** (Final Stage) – Teams will be required to demonstrate the full functionality of the Hospital Service Robot in an environment set or modified by judges. Stage 3 competition is planned to be a physical gathering subject to COVID-19 restrictions and financial viability. If the physical gathering is not possible for any reason, then the final stage will be held online.

For Stage 2 & 3, R10 will specify the assessment rubrics to evaluate the performance of the robots as well as the teams' performance in achieving the competition objectives. The broad judging criteria for each stage are given below. At each stage, entries will be judged for the technical content, innovation, practical implementation, documentation and potential for further development of the robot into a marketable product.

#### **4. General Rules**

1. The robots should be built from scratch and must not use commercially available robots to enter the competition.
2. Robots must not have any sharp edges or corners and spiky parts that can cause injury to anyone.
3. For Stages 2 and 3, participants must upload all documentation through a portal by the closing dates announced by R10.
4. The competition will be conducted in English, i.e., all submissions, including project documentation must be in English. However teams will be allowed to arrange the services of a translator to answer judges' questions at all three stages of the competition.
5. The deadlines for each stage will be posted on the R10 Robotics Competition website. Contestants are required to check and ensure meeting the deadlines.
6. The judges' decision will be final in all three stages, and no appeal against the judges' decision will be entertained.
7. R10 Director can cancel the competition if the participation rate is very low or for any other reason deemed by the R10 Director as valid for the cancellation.

#### **5. Problem Description**

There is always a risk of spreading pathogens in hospital wards, especially the highly transmissible viruses like variants of COVID-19. This virus spreading risk can be reduced by using robotics to carry out various tasks like serving food to patients, thus preventing the virus from spreading by reducing the interaction between humans. In addition, robots can be easily sanitized between tasks.

A Robot is required to help with the distribution of the food trays with the following duties:

- Collect food tray from a food distribution area (Pick Up Zone) and deliver it by placing it on the table near the patient's bed;
- Food trays at the Pick Up Zone are placed randomly but marked for each patient. Each food tray must be correctly delivered to the designated patient. The food trays can be color-coded or numbered corresponding to the Delivery Area;
- Avoid collision with any human or object in its path and successfully cross uneven surfaces without dropping the items on the food tray.
- Collect trays after food consumption and return them to a designated area marked as "Food Trays Return Zone."
- At the "Food Trays Return Zone," sort out the items on the tray into "Reusable Items," such as cutlery and glass plates, and items for recycling such as plastic bottles and anything made of paper.

#### **5.1 Critical Features & Functions of a Hospital Service Robot**

##### **5.1.1 Features**

1. Ability to read the delivery information using machine vision and object recognition techniques to pick up the food tray for delivery;
2. Able to move and navigate around objects and reach the designated Deliver Area;

3. Place the food tray on the table safely without dropping any object at the designated Delivery Area;
4. Ability to move across uneven surfaces, such as inclined and sloped surfaces;
5. Safety features
  - a. Collision avoidance with obstacles and humans;
  - b. Prevention of dropping items from the food tray;
  - c. Emergency “Stop” button for human intervention. The button must be notably visible and colored red for attention;
  - d. If the robot has a laser feature, the laser should be class 2 or less. From the design to practice stages, full care must be taken to ensure that the use of laser does not pose any danger to the eyes of anyone at the venue;
  - e. Lead-acid batteries (including colloidal), power sources that involve flames and/or high temperatures, anything that may contaminate the operational field, as well as anything that may cause the robots to break down and/or create a situation that hinders the progression of the competitions are prohibited;
  - f. No sharp edges or spiky parts - Robots must be designed and built not to pose any danger to anyone, including the team, the opposing team, and the people in the surrounding. In addition, the robot should not be easily tripped over.

### **5.1.2 Functions**

1. Robot functions autonomously without intervention or assistance from an operator except for the initial power-on procedure;
2. Detect proximity to other objects and avoid a collision;
3. Pick up the food tray and read the delivery location;
4. Autonomously move around to deliver the food tray and collect them in a time-efficient manner after the judges give the food consumed signal;
5. Sort out objects on the tray into “Reusable” and “Recycle” categories and place them accordingly at the “Food Trays Return Zone” (RZ)

### **5.2 General Specifications**

1. The robot must be autonomous and must not be controlled by an operator by any wireless link (Bluetooth, Wi-Fi, or any other form of communication).
2. The maximum size of the robot should be within 40cm (W) x 40cm (L) x 60 cm (H).
3. There is no restriction on the weight of the robot.
4. The DC power source of 1 2V I 24V I 36V could be employed.
5. The total cost of the robot should not exceed USD 1000.
6. Any noncompliance of above specifications may disqualify the robot from the competition.

### **5.3 General Requirements & Restrictions**

- The participants cannot use a Commercial off the Shelf (COTS) robot.
- Robots must not be controlled remotely and must operate autonomously once the competition round has started.
- Document and report only what is required for each Stage. Participants can work on the next stage of the competition but are not required to early report the work of the next stage(s).

- Rough sketches and notes will NOT be accepted as proper engineering notes/reports. Instead, participants must properly document robot design features, subsystems components with interconnections, and algorithms coded.
- The competition will be conducted in English, i.e., all submissions, including project documentation must be in English.

## 5.4 Terms and Definitions

The definitions of terms & abbreviations used for this competition are given in Table 1 below.

**Table 1 Definitions of Terms and Abbreviations**

Term/Abbreviation	DEFINITIONS
Robot	The <b>Robot</b> that carries and places the ‘food tray’ in the respective areas;
FT	<b>Food Tray</b> - The tray which holds some objects/liquids that mimics food items;
SZ	<b>Start Zone</b> - Area where the Robot starts its operation and return at the end of the round;
PZ	<b>PICK UP ZONE</b> - Region where the Robots will pick up the food tray;
DA	<b>Delivery Area</b> – Patient’s room where the robots place the food trays;
RZ	<b>Return Zone</b> – Area marked to return food trays after consumption of food;

## 6 Stage-wise Competition Requirements

Participants are required to build the robot capable of performing duties specified for each stage below.

### 6.1 Stage 1

In Stage 1, participants are expected to study the problem, understand the requirements, decompose requirements, and determine system architecture for gradual enhancements in robot capabilities. In addition, the design must conform to safety requirements. The layout of the operational field is given in Figure 1 and Figure 2.

#### 6.1.1 Objectives for Stage 1

- Study and decompose Hospital Service Robot requirements to:
  - Contemplate design features of the Robot to meet requirements,
  - Determine required subsystems,
  - Comprehensive consideration of all the components, coding, and subtasks for the robot with provision for enhancements for Stages 2 and 3.
  - Develop a plan of work identifying key milestones with timelines and potential project risks
- Build subsystems and integrate them into a working Hospital Service Robot suitable for Stage 1 tasks listed below in section 6.1.2.

- Documentation – It is essential to maintain proper documentation to record design considerations and decisions, technical details of assumptions made for the design, algorithms developed and tested, testing methods with results.

### **6.1.2 Robot Tasks for Stage 1**

- Start from the designated “Start Zone” (SZ) and move to the “Pick Up Zone” (PZ).
- Pick up the food trays from the PZ and deliver them to the patient by matching colors of the food tray and the table at the “Delivery Area” (DA). The food trays carry solid and liquid items, which should not be dropped or spilled while handling the food trays.
- When more than one food trays are to delivered, then the robot needs to work out the most time-saving delivery plan and deliver the trays correctly. However, the food trays carry solid and liquid items and cannot be stacked for delivery.
- After delivery, return to SZ and wait. After 30 seconds, go to only those DAs where the food trays were delivered and bring back food trays to the “Return Zone” (RZ). Food trays can be brought back one by one or all in a single trip by stacking them, whichever is the quickest way to return all trays to the RZ.

### **6.1.3 Judging Criteria for Stage 1**

Stage 1 assessments will be conducted by the local IEEE Section using the following judging criteria:

1. Documented design consideration made for the Robot
2. Working functions of the Robot,
  - (a) Autonomous actions and operation,
  - (b) Object recognition and read color-coded delivery address,
  - (c) Strategy and exactness of movement to deliver the food tray in minimum time,
  - (d) Strategy and exact movement to return the food trays to the Return Zone in a time-efficient manner.
  - (e) Handling of food tray – penalties for dropping or spillage of items on the tray/floor
3. Safety features – Number of safety features incorporated from the list given in section 5.1.1.
4. Quality of documentation.

## **6.2 Stage 2**

In Stage 2 team will enhance the robot developed in Stage 1 to operate in a field shared by other objects and people. The layout of the operational field is given in Figure 3 and Figure 4.

### **6.2.1 Objectives for Stage 2**

- **Learning Objectives**
  - Development of a comprehensive plan to enhance the Hospital Service Robot based on work in Stage 1. The plan must identify key milestones with timelines and potential project risks;
  - Application of project management principles and teamwork;

- Documentation.
- **Technical Objectives**
  - Review design features for enhanced functioning of the Hospital Service Robot.
  - Instead of color-coded trays, read the Food Tray number or QR code and deliver to the corresponding patient’s room.
  - Collision avoidance by detecting proximity to other objects on the field and circumnavigating them.
  - Analyze and work out the number of Food Trays to be delivered in the most time-efficient manner.
  - Documentation – Record Hospital Service Robot enhancements with test results. The documentation must follow the guidelines given for Stage 1.

### **6.2.2 Robot Tasks for Stage 2**

- Start from the designated “Start Zone” (SZ) and move to the “Pick Up Zone” (PZ).
- Pick up the food trays from the PZ and deliver them to the “Delivery Area” (DA) by matching the food tray number or QR code and patient room number. The food trays carry solid and liquid items, which should not be dropped or spilled while handling the food trays.
- If there are more than one Food Trays to be delivered, then work out the most time-saving delivery plan and deliver the trays accordingly. The food trays carry solid and liquid items and cannot be stacked for delivery.
- Detect other objects and avoid collision with them.
- After delivery, return to SZ and wait.
- On signal from the judges, go to only those DAs where the food trays were delivered and bring back food trays to the “Return Zone” (RZ). Food trays can be brought back one by one or all in a single trip by stacking them, whichever is the quickest way to return all trays to the RZ.

### **6.2.3 Submission Requirement**

For Stage 2 participation, teams will be required to submit:

- (1) A submission form with team details and endorsed by the Section Chair or by someone authorized to endorse on behalf of the Section Chair.
- (2) A 6-minute video presentation in mp4 format, showing the performance of the Robot with explanation of key innovative feature incorporated into the robot design.
- (3) Project Engineering Notebook (pdf format) showing work breakdown with team members responsible for the task and timelines, project completion on time and within available resources. This documentation can be an updated version from Stage 1 or a new document.
- (4) A plan for further development of the robot to meet Stage 3 requirements. The estimated budget with a cost breakdown must be included in the plan. Teams who do not submit this plan may not qualify for R10 funding.

#### **6.2.4 Judging Criteria for Stage 2**

At Stage 2, the judging will be conducted by the R10 judging panel based on (a) project video presentation, (b) quality of documentation, and answers to questions asked by the judging panel. The broad judging criteria for Stage 2 may include:

1. The originality of the research conducted and the solution worked out to meet the Robot's functional requirements.
2. Working functions of the Robot:
  - a. Autonomous actions and operation;
  - b. Object recognition and read delivery address;
  - c. Strategy and exactness of movement to deliver the food tray in minimum time;
  - d. Collision Avoidance – Detect proximity to objects and circumnavigate to avoid collisions with objects such as hospital trolleys, decoration pieces, and people;
  - e. Strategy and exactness of robot movements to return the food trays to the Food Trays Return Zone in a time-efficient manner;
  - f. Handling of food tray – penalties for dropping or spillage of items on the tray/floor.
3. Hospital Service Robot performance demonstration in the video.
4. Safety features – Number of safety features incorporated from the list given in section 5.1.1.
5. Documentation quality
  - a. Evidence of thought process for developing the project plans, identification of potential risks, and risk mitigation strategies,
  - b. Design details, software code, and testing procedures with results,
  - c. Evidence of teamwork by adopted project management practices and achievement of project milestones.
6. Video (Clarity and quality of video, quality of technical content, and factual and technical accuracy)
7. Answers to questions asked by the judging panel.

#### **6.3 Stage 3**

Stage 3 is the final stage in which teams will be required to physically participate with their functional Hospital Service Robots.

##### **6.3.1 Objectives for Stage 3**

- **Learning Objectives**
  - Breaking down a complex problem into manageable tasks for tackling technical challenges;
  - Application of project management principles and teamwork;
  - Documentation and technical paper writing.
- **Technical Objectives**
  - Enhance the Hospital Service Robot to operate in the presence of stationary objects, moving people, and uneven surfaces (ascent and descent);

- Balancing the load while crossing an uneven surface;
- Objects classification and unloading them in appropriate receptacles;
- Technical Report – documenting methodology, test results, and specifications of the prototype Hospital Service Robot;
- Write a conference paper and a business plan for commercial development.

### **6.3.2 Robot Tasks for Stage 3**

- Start from the designated “Start Zone” (SZ) and move to the “Pick Up Zone” (PZ).
- Pick up the food trays from the PZ and deliver them to the “Delivery Area” (DA) by matching the food tray number or QR code and patient room number. The food trays carry solid and liquid items, which should not be dropped or spilled while handling the food trays.
- If there are more than one Food Trays to be delivered, then work out the most time-saving delivery plan and deliver the trays accordingly. The food trays carry solid and liquid items and cannot be stacked for delivery.
- Detect other objects and avoid collision with them.
- Detect uneven surface and cross it safely without disturbing the items on the food tray. For crossing inclined and declined surfaces, the robot can adjust its speed to maintain balance for itself and the load.
- After delivery, return to SZ and wait.
- On signal from the judges, go to only those DAs where the food trays were delivered and bring back food trays to the “Return Zone” (RZ). Food trays can be brought back one by one or all in a single trip by stacking them, whichever is the quickest way to return all trays to the RZ.
- At the RZ sort out items on the tray into “Reusable” and “Recyclable” items and place them accordingly on the rack or in the bin. For example, all cutlery and ceramic objects are considered “Reusable,” and all objects made of plastic and paper can be considered “Recyclable”.

### **6.3.3 Submission Requirement**

For Stage 3 assessments, teams will be required to submit:

1. A 6-minute video presentation in mp4 format;
2. Project Engineering Notebook (pdf file) shows work breakdown with team members responsible for the task with timelines and completion of the project on time and within budget;
3. Two team members will be required to physically attend the final round with the Robot to demonstrate its working. Robot performance will be assessed during competition rounds at a venue arranged by R10;
4. A business plan detailing the development phases and cost for turning the prototype robot into a marketable robot.
5. The draft of a paper ready for submission to a conference. A previously published paper will not be accepted.

### 6.3.4 Judging Criteria for Stage 3

Following judging criteria will be used for the assessments of the submitted robot in Stage 3:

1. Robot performance during the rounds on a scaled field. The details of the competition rounds are given below. The field set up for the competition rounds is shown in Figure 3.
3. Scoring will be done using all the judging criteria for Stage 2 plus the below ones:
  - a. Hospital Service Robot's performance in the presence of stationary objects, moving people, and crossing uneven surfaces (ascent and descent);
  - b. Balancing the load while crossing an uneven surface;
  - c. Objects classification and unloading them in appropriate receptacles to separate reusable items from things for recycling;
  - d. Strategies to optimize the time for Food Trays deliveries and return to the Food Trays Return Zone (RZ);
2. Demonstrated robustness of safety features;
3. Evidence of project management practices applied in the project;
4. Quality of technical documentation;
5. A written business plan, predicting the commercialization potentials, risk mitigation strategies, and R&D budget. A conference paper will get bonus points;
6. Answers to questions asked by the judging panel.

The above list is not exhaustive, and the judging panel may look into other factors if required. If R10 cannot arrange a physical gathering, the video presentation will be used to judge. In addition, the team leader and members will be required to be present to answer questions.

### 6.3.5 Competition Rounds

The final rounds of stage 3 will be conducted at a venue arranged by R10. The field for the operation of the Robot is given in Figures 5 & 6. Before the start of competition rounds, all Robots will be checked for the specified size limits and for safety features given in section 5.2. Any noncompliance of specifications may disqualify the robot from the competition.

The procedure for the rounds will be as follows:

#### 1. Set-up

- a. For each round, a one-minute set-up time is allocated to the teams through the signal from the referee.
- b. The robot must be placed in the Start Zone (SZ) before the set-up time.
- c. The team members must prepare their robot in SZ once the signal is given. Each team shall initiate the set-up time once the signal is given and must stop when the one (1) minute is over.
- d. In case a team fails to complete their preparation within the given time then the team may resume the preparation upon starting the round by obtaining permission from the referee but will lose time from round time.

#### 2. Round Proceedings

- a. After the set-up time ends, the round shall begin at the signal from the referee;
- b. Teams that complete their set-up after the start of the round need to obtain permission from the referee before moving their robot;

- c. No team members can enter the field without permission from the referee;
- d. No team members can touch their robot except after the referee gives permission during the start of a round and a retry;
- e. Only one preloaded 'Food Tray' needs to be picked up at a time;
- f. The 'Food Tray' needs to be carried to the 'Delivery Area' according to tray number or QR code and the corresponding delivery points;
- g. Once the robot successfully places the 'Food Tray,' then it may return to the "Pick Up Zone" (PZ) to pick up another 'Food Tray.'
- h. If the 'Food Tray' or objects on it fall down to the floor during a round, that 'Food Tray' becomes invalid and can no longer be used.

### 3. End of the Round

- a. Once a team finishes all the tasks, the game ends;
- b. The game shall also end if the game time passes the fixed time limit;
- c. The game shall also end if the team uses up all the given 'Food Tray'.

### 4. Scoring

The Robot performance will be scored for the following:

- a. The number of tasks finished during the round;
- b. Time taken to complete tasks;
- c. Negative scores as a penalty for mistakes or failures.

The above scores will be combined with marks for judging criteria to pick the team as the winner.

### 7. Prizes

The R10 Robotics Competition will offer an attractive prize scheme to encourage innovation and entrepreneurship, promote STEM and enhance IEEE visibility in the communities. Generally, the prize scheme will consist of:

**Stage 1 Prizes:** These will consist of certificates and maybe cash prizes depending on the sponsorship from the local industry and relevant government departments. Sections would also be encouraged to invite local school children to participate in the competition and offer them some prizes for encouragement and inspiring them to study STEM subjects.

**Stage 2 Prizes:** In Stage 2, the top teams will win the financial support to enhance their robots and improve their chances to be successful in the final stage (Stage 3) of the competition. Those not able to qualify for Stage 3 but demonstrate innovative/interesting ideas in Stage 2 will get a consolation prize.

**Stage 3 Prizes:** The prize scheme for Stage 3 will consist of

1. One Grand Prize of the competition
2. Prizes for the competition project:
  - a. A cash prize for the first position and a certificate,
  - b. A second position cash prize equivalent to 70% of the first cash prize plus certificate, and
  - c. A third position prize equivalent to 50% of the first cash prize plus certificate.

3. There will be one special prize for IEEE Women-in-Engineering members for the encouragement of young women studying engineering-related courses or working in engineering professions. This is expected to inspire young females to study STEM courses.

It will be up to team members to decide how to split the cash prize among team members who are IEEE members. Cash prizes are not for non-IEEE members but they can receive participation certificates.

R10 Director can approve a different cash prize arrangement instead of above mentioned scheme. The prizes for 2022 will be announced on the R10 Robotics Competition website.

## **8. Important Dates**

### **8.1 Important Dates for Contestants**

R10 Robotics Competition Start Date: Monday, 07 March 2022

#### **Stage 1**

- **Teams' working period:** 7th March 2022 – Closing date fixed by the local IEEE Section, which should not be later than 15 May 2022.
- **No later than 30 May 2022:** Selection of Projects Team by the IEEE Section
- **Friday, 10th June 2022:** Deadline for IEEE Sections to inform R10 about the teams for Stage 2.

#### **Stage 2**

- **1st June 2022 – 31st July:** Teams' working period
- **30 June 2022:** Deadline for Teams Registrations with R10
- **05 August 2022:** Deadline to submit competition material to R10
- **21 & 22 August 2022:** R10 online Stage 2 Competition
- **28th August 2022:** Announcement of Stage 2 winners.

#### **Stage 3**

- **29th Aug – 16th Oct:** Teams working period
- **17 Oct 2022:** Deadline to submit competition material to R10
- **1st – 4th November 2022:** Two-day **R10 Level Competitions** (R10 will confirm the exact dates and venue on Sunday 22 August 2022 at Stage 2).

### **8.2 Important Dates for IEEE Sections**

- **31 March 2022:** Deadline for submitting R10 Funding Proposal
- **15 April 2022:** R10 intimation of accepted proposals for funding
- **25 March – 30 July 2022:** Sections to organize local robotics activities
- **25 March 2022:** IEEE Section to announce a Stage 1 Closing Date, which should not be later than 15 May 2022
- **No later than 30 May 2022:** Selection of Teams by the IEEE Section for Stage 2
- **10 June 2022:** IEEE Sections to inform R10 about the teams for Stage 2
- **15 August 2022:** Section robotics activities report for payment of approved R10 funding.

- 30 October 2022: Funds transferred by R10 to Sections

## FIGURES

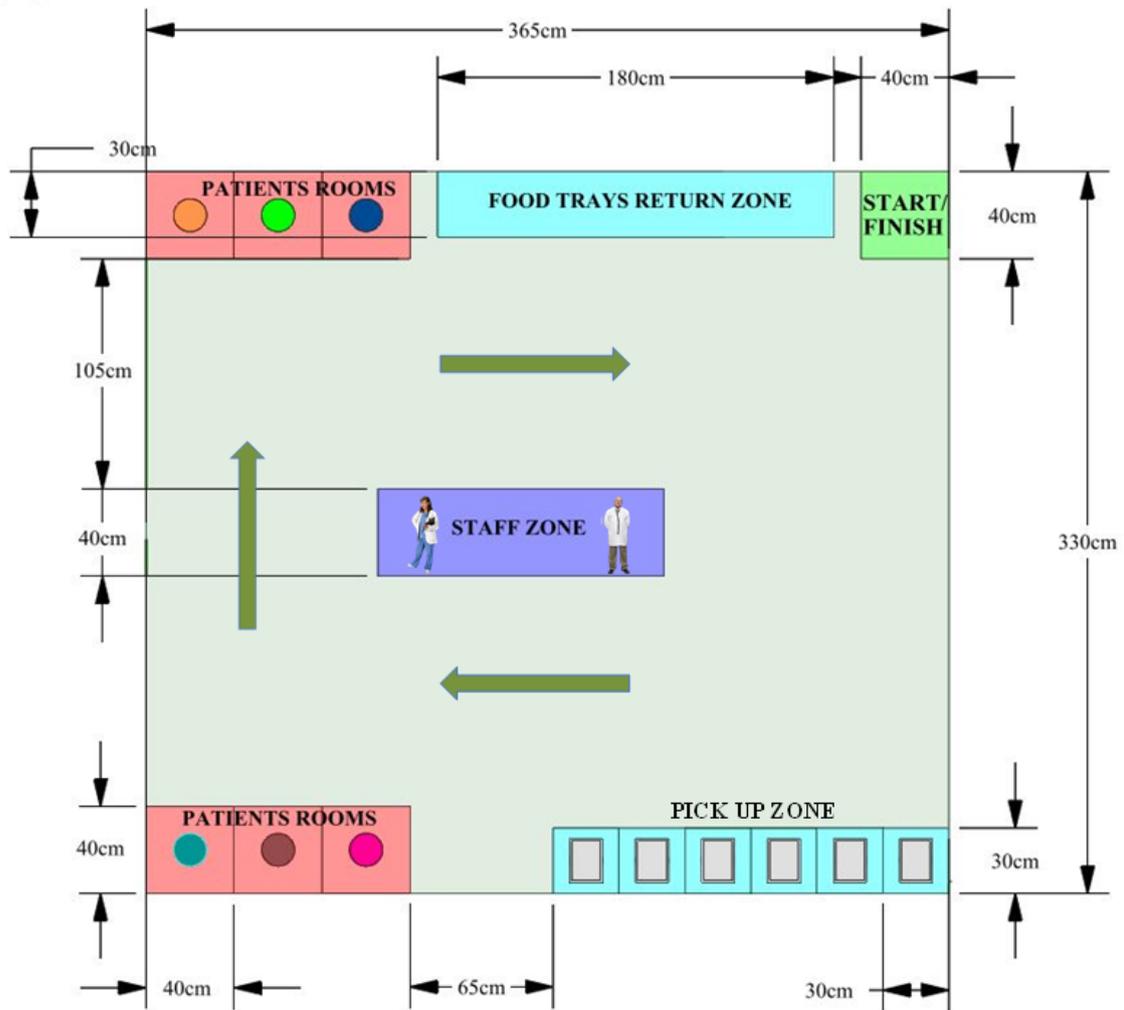


Figure 1. Top view of the robot's operation zone for Stage 1.

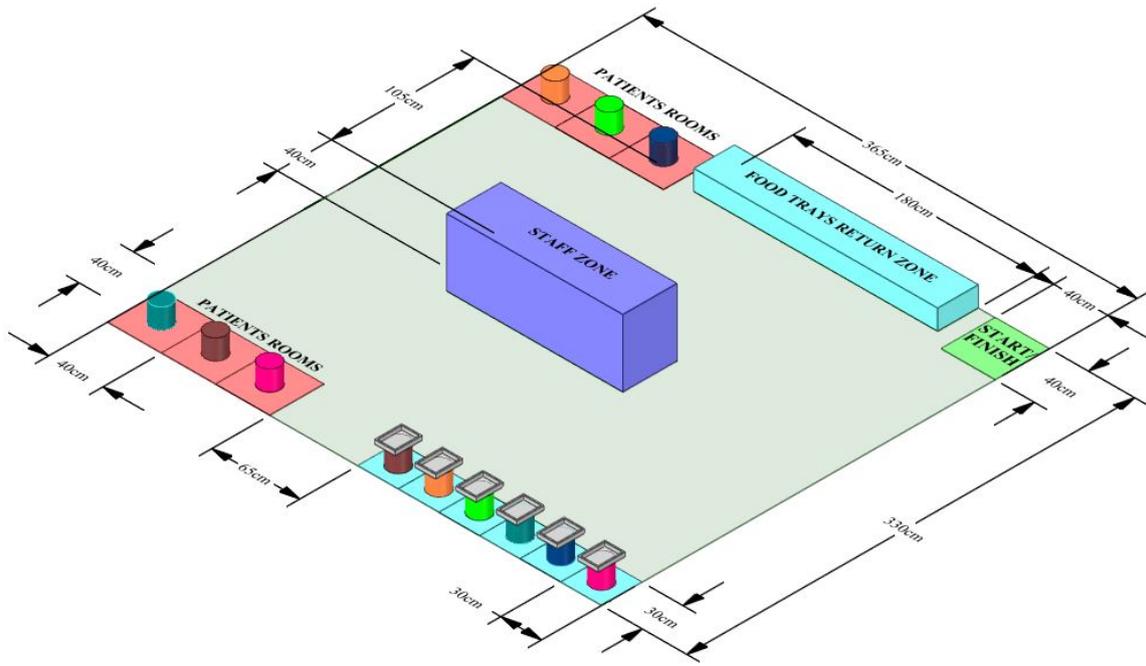


Figure 2. Isometric view of the robot's operation zone for Stage 1.

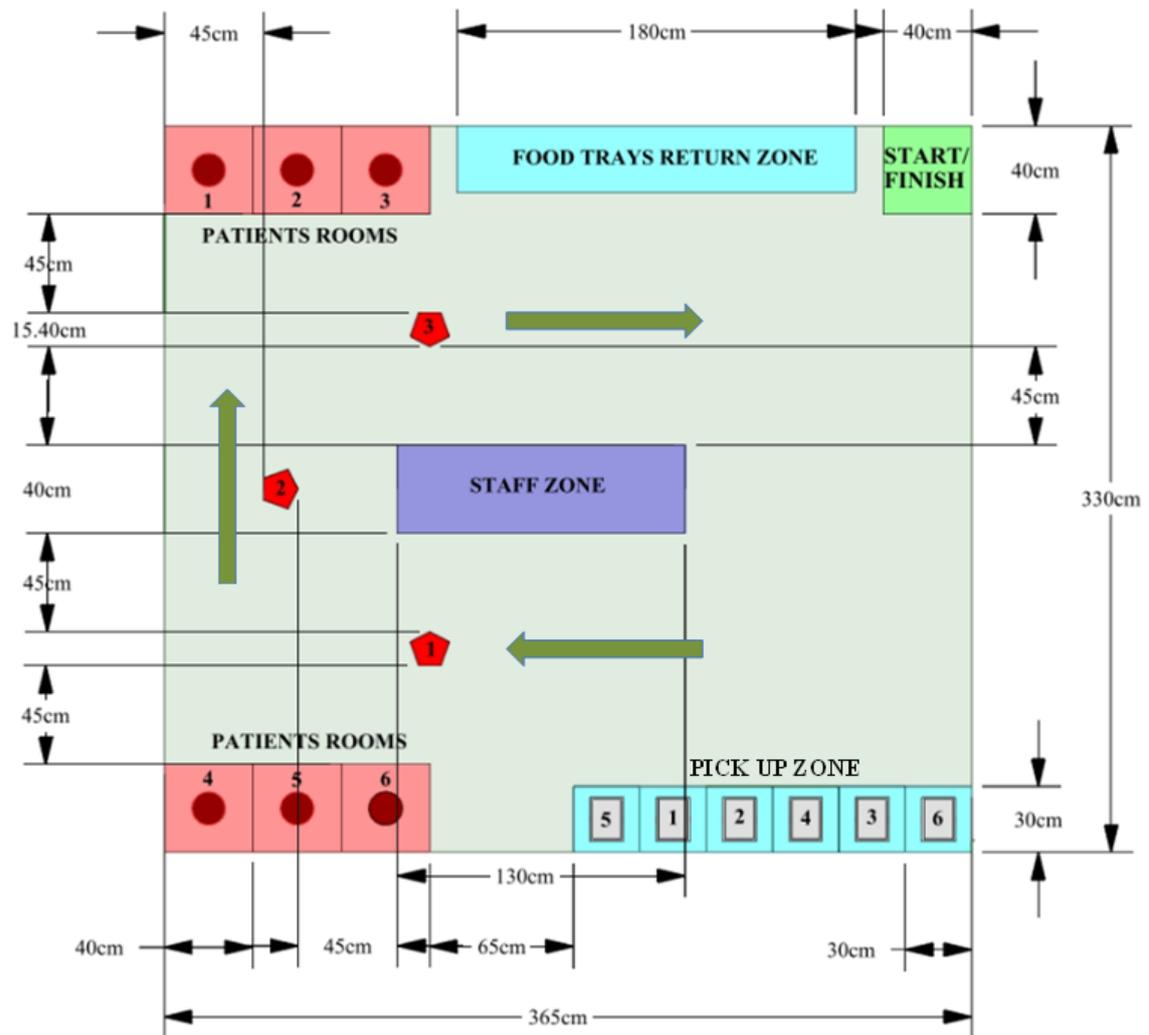


Figure 3. Top view of the robot's operation zone for Stage 2.

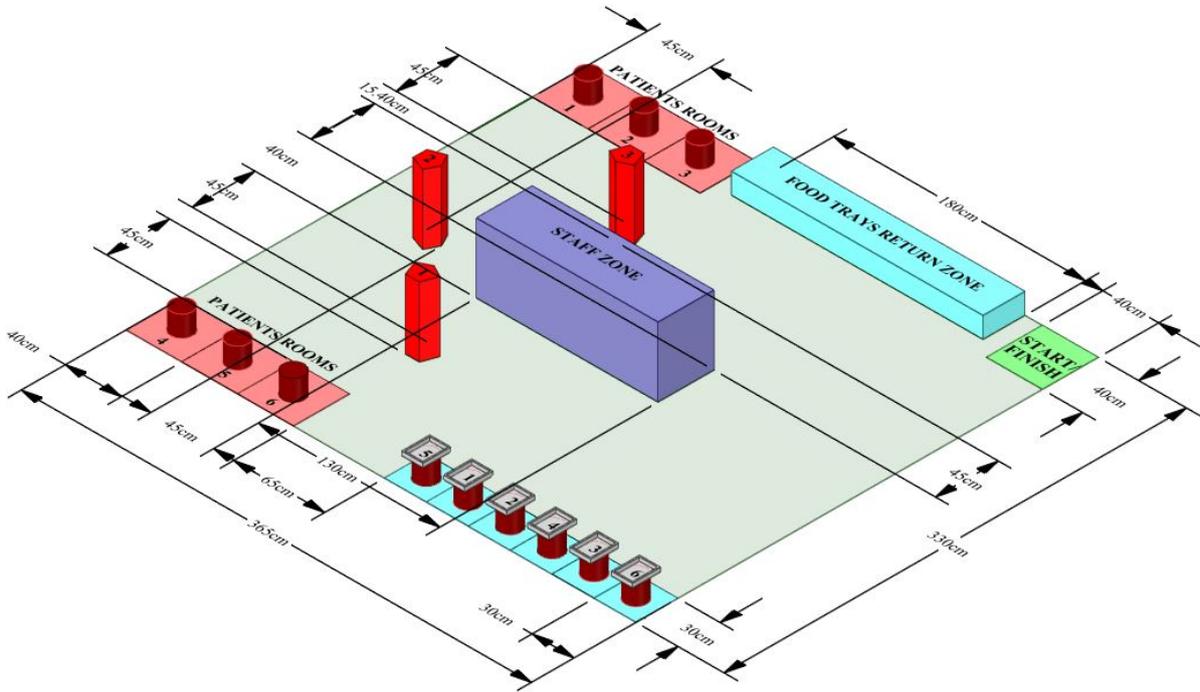


Figure 4. Isometric view of the robot's operation zone for Stage 2.

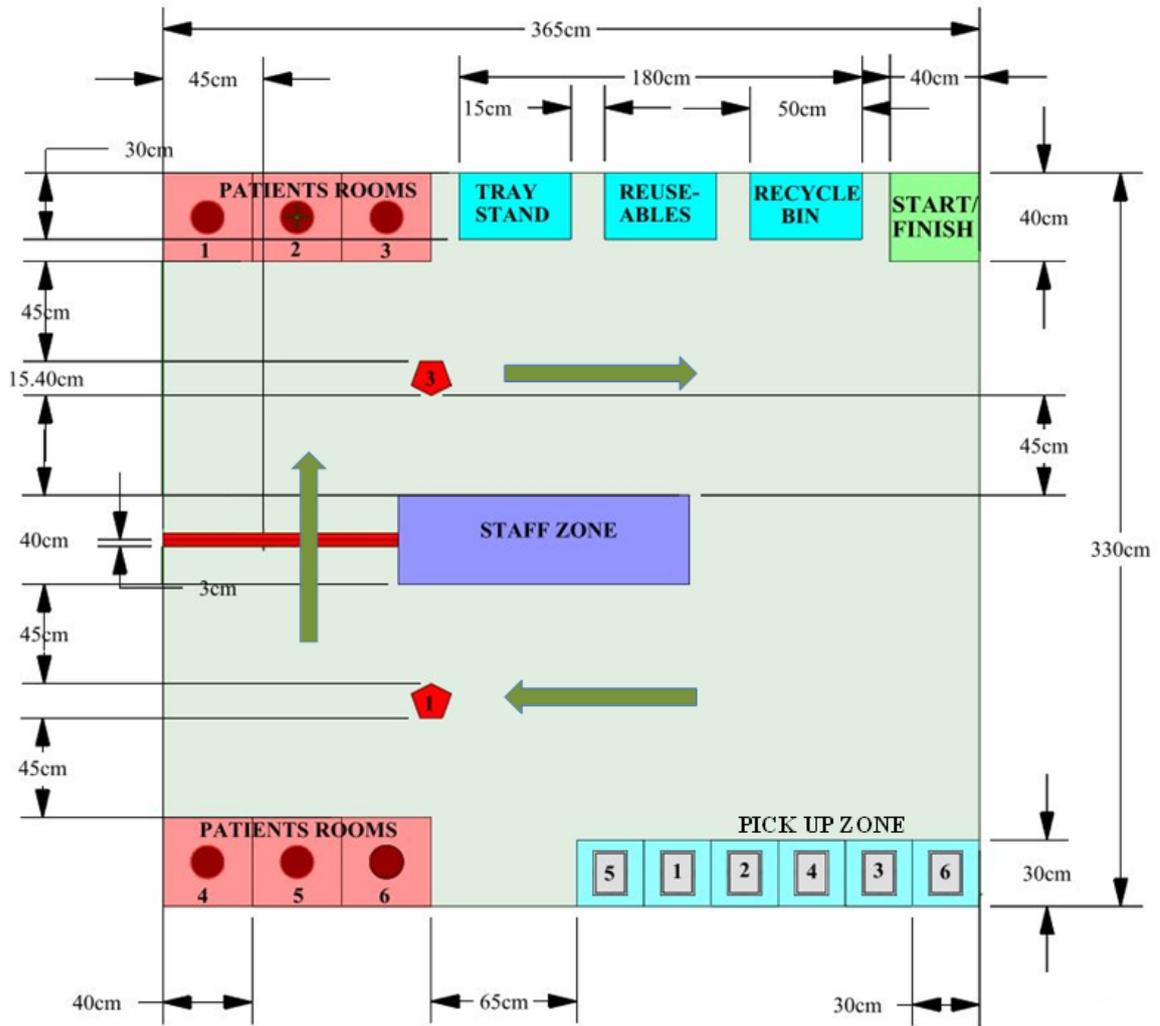


Figure 5. Top view of the robot's operation zone for Stage 3.

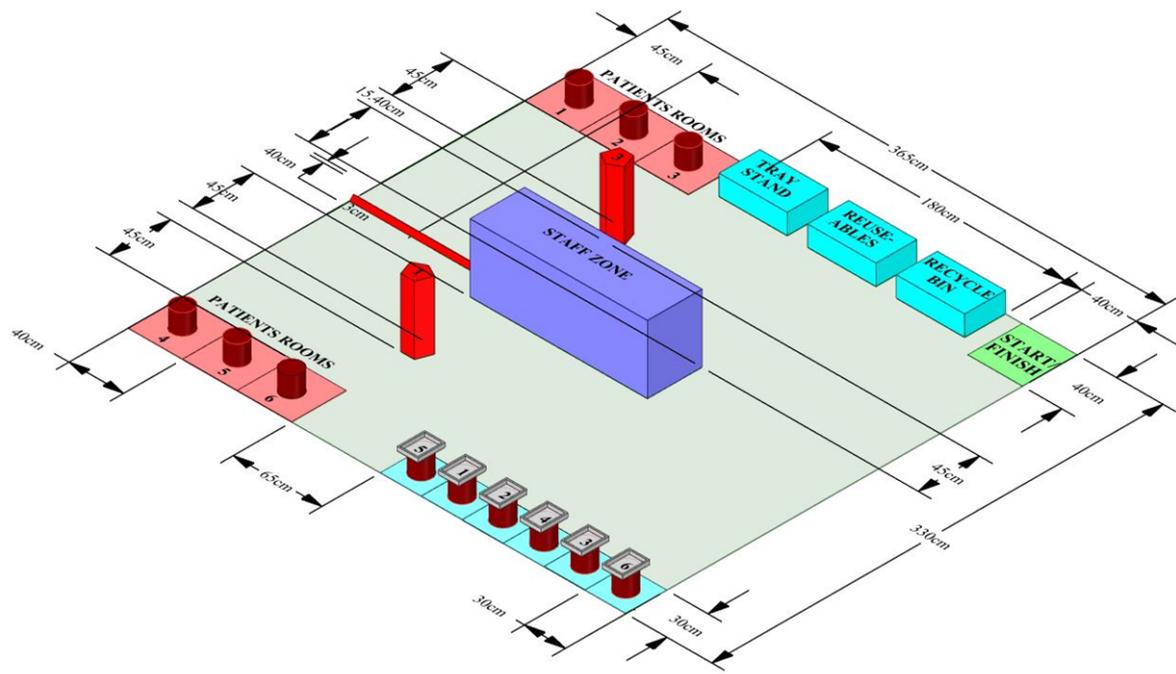


Figure 6. Isometric view of the robot's operation zone for Stage 3.