Ant Bot

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1. List of Abbreviations:

Sr. No.	Abbreviation	Full form
1	AB	Ant Bot
2	AH	Ant Hill
3	AH Wall	Ant Hill Wall
4	BB	Blue Block
5	CN	Central Node
6	CSD	Correct SIM Detection
7	CSED	Correct Service Execution Drop
8	CSEP	Correct Service Execution Pick
9	CSI	Correct Service Identification
10	DB	Design Bonus
11	GB	Green Block
12	H	Honeydew
13	L	Leaves
14	OB	Overall Bonus
15	P	Path
16	QAH	Queen Ant Hill

Sr. No.	Abbreviation	Full form
17	QB	Bonus for Servicing QAH
18	RAH	Regular Ant Hill
19	RB	Red Block
20	RN	Regular Node
21	S	Supply
22	SA	Shrubs Area
23	Serv	Service Location
24	Serv 1	Service Location 1
25	Serv 2	Service Location 2
26	SIM	Service and Identification Marker
27	T	Trash
28	TDZ	Trash Deposition Zone
29	TR	Trash Removal
30	W	Wood
31	YB	Yellow Block

2. Introduction:

Marching along the jungle safari are "**Ants**" that keep the jungle going. We notice **cooperation** and **coordination** in their work - the essential aspects of teamwork. We have tried to depict the work of a single ant in our **Ant Bot (AB)** theme.

An Ant collects and provides food for not just itself but also its community while leaving a trail for other ants to follow. The Arena is designed such that the first ant has left a black path behind for the other teammates. **Thus, your bot is the teammate AB.**

The tasks to be done by AB across the arena are the same as the first ant i.e. collecting leaves, honey, wood from the **Shrubs Area (SA)** and store for winter and/or remove trash from its **Ant Hills (AH)**. One of the Ant Hills, the **Queen Ant's Hill (QAH)** is always given preferential treatment while doing the service. These tasks and the rules associated with them are mentioned in further sections.

The challenges in this theme include Line Following using a sensor, colour image processing and AH detection and service assessment using a Camera; in addition to these there is also a requirement to design and build pick and place mechanism.

The team that finishes the given task in the least amount of time whilst incurring the least penalties will be declared the winner.

All the best!!!

3. Theme Description:

The arena and its components are as shown in figure 1. A **colony** of ants has been abstracted on an arena.
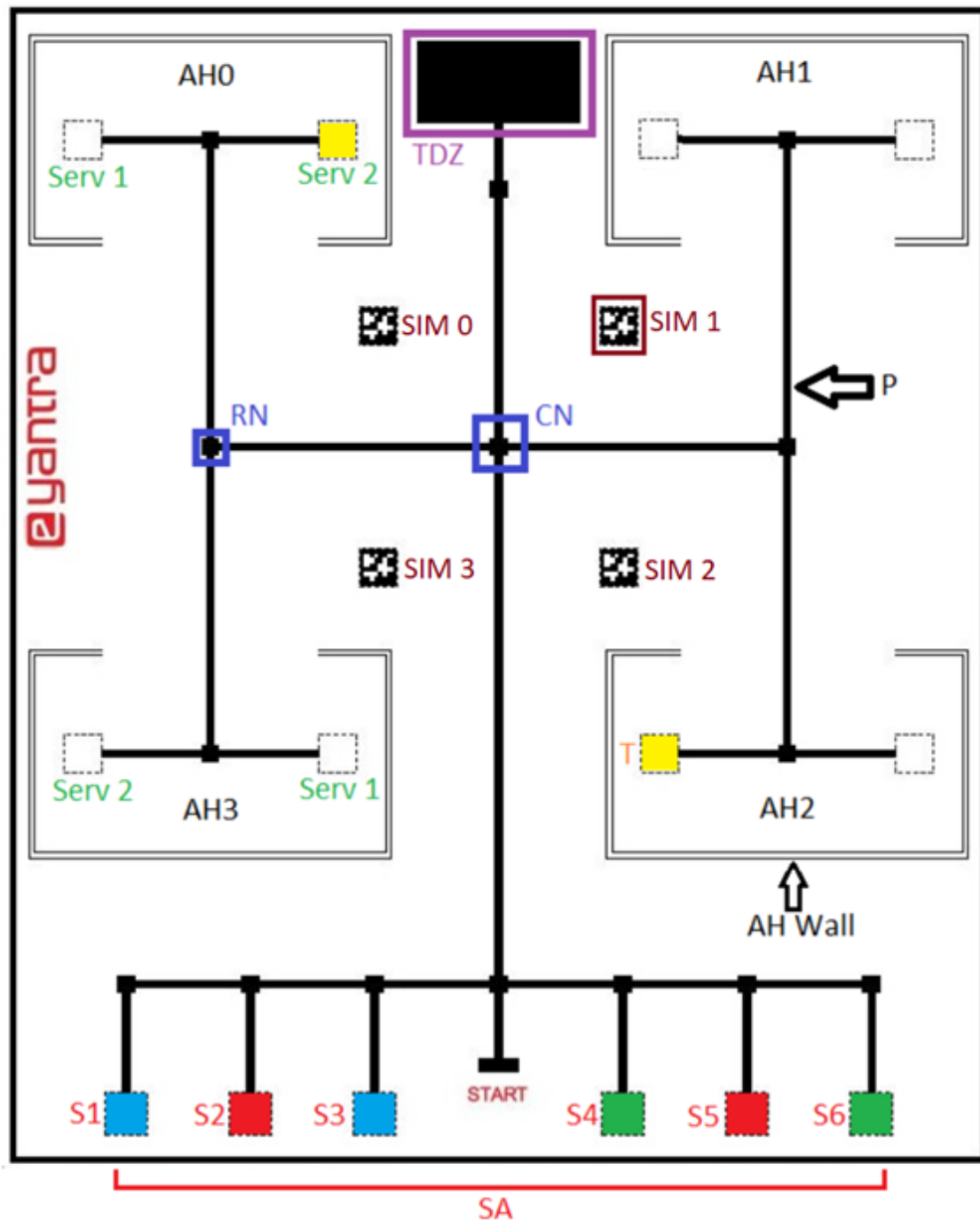

Figure 1: Arena and its components

With reference to Figure 1, we define the following:

Note: The placement of Supply Blocks (S1 to S6) & Trash Blocks (T) shown in Figure 1 is just for illustrating terms. During the competition the placement will be different.

Start: The starting point of the path of Ant Bot (AB) is defined as the "**START**". The AB must be placed at the START, facing the Ant Hills (AH) at the start of each Run.

Ant Hill (AH): Ant Hill (AH) is defined as the area where ants live. They carry required **Supplies** to the AH and remove **Trash** from the AH. There are 4 such AHs depicted in the arena as Ant Hill 0 (AH0), Ant Hill 1 (AH1), Ant Hill 2 (AH2) and Ant Hill 3 (AH3). One of the AH is a **Queen Ant Hill (QAH)** which is a priority AH for providing Services while other are **Regular AH (RAH)** and are always of less priority than QAH. The information regarding which AH is QAH is present in Service and Identification Marker (SIM) (discussed in further points).

Note: There can be a **maximum** of ONLY one QAH.

Node (N): A Node is a small Black square of dimension 3cm x 3cm. The Node present in the centre of arena is called as the **Central Node (CN)**. All AHs are equidistant from the **Central Node (CN)**. All Nodes other than the CN are called as a **Regular Node (RN)**.

Service and Identification Marker (SIM): A Service and Identification Marker (SIM) i.e. an ArUco marker is associated with each AH. Ant Bot identifies the Ant Hill number (AH0/AH1/AH2/AH3), its category (RAH or QAH) and the type of Service required by Ant Hill from the SIM. As shown in Figure 1, SIM 0 is associated with AH0, similarly, SIM 1 with AH1, SIM 2 with AH2 and SIM 3 with AH3.

Service Location (Serv): A Service location is defined as the place where AH requires Service such as placing **Supply (S)** or **Trash Removal (TR)**. For a given AH there are two Service locations, Service Location 1 (Serv 1) and Service Location 2 (Serv 2). These Service Locations may have Service requirement in one of the combinations as shown in table below:

Table 1: Service Requirement combinations

Service Location 1 (Serv 1)	Service Location 2 (Serv 2)
Supply Requirement	Supply Requirement
Trash Removal	Supply Requirement
Supply Requirement	Trash Removal
Supply Requirement	No Service required
No Service required	Supply Requirement
Trash Removal	No Service required
No Service required	Trash Removal
No Service required	No Service required

For a given AH, Serv 1 is always the Service at the left from AH entrance and Serv 2 is always the Service at the right from AH entrance.

Note: Any Service location can have a maximum of only one kind of Service associated with it, i.e. a given Service location (Serv 1 or Serv 2) may have Supply Requirement as a Service or Trash Removal as a Service or none. It cannot have Trash Removal (1st Service) and Supply Requirement (2nd Service) or any such or similar cases requiring Two Services at one Service location.

Supply (S): An Ant Hill may have Supply Requirements as a Service requirement. These Supplies are present in the **Shrubs Area** (**SA**). There are total of 3 types of Supply as **Honeydew (H), Leaves (L)** and **Wood (W).** Supplies are denoted by blocks of Red, Green and Blue colour where, **Red Block (RB)** denotes Honeydew (H), **Green Block (GB)** denoted Leaves (L) and **Blue Block (BB)** denotes Wood (W). There are such 6 locations in the Shrubs Area for placing these supplies namely Supply 1 (S1), Supply 2 (S2), Supply 3 (S3), Supply 4 (S4), Supply 5 (S5) and Supply 6 (S6).

Shrubs Area (SA): This area contains the three types of supplies as mentioned above.

Note: There can be a **maximum** of Two (2) of one type of supply For example, Two (2) Leaves depicted by Green Blocks. However, there will be at least one Supply placed in the Shrubs Area.

Trash Deposition Zone (TDZ): This is an area denoted by a black patch of 30 cm x 15 cm where Trash from AH is deposited for AH having Trash Removal as a Service requirement.

Trash Removal (TR): An AH may have Service requirement as Trash Removal (TR). The **Trash (T)** may be present in an AH at either Serv 1 or Serv 2 and is denoted by a **Yellow Block (YB)**. Trash has to be removed from the AH and deposited in the **Trash Deposition Zone (TDZ).**

Path (P): Path connects AHs, SA and TDZ.

AH Wall: It is the wall present at the boundary of an AH. More details about construction and placing are provided in Section 4 where we describe the Arena.

We define the terms and inputs as follows:

SIM: SIM is an ArUco marker that contains the information about the AH it is associated with. It is an ArUco marker belonging to dictionary DICT_7X7_1000. The ID of the marker (decimal number of the ID) contains the following data bit-wise:

i.   Bit-7: If this bit is "1", it denotes AH to be QAH. Otherwise, AH is RAH.

ii. Bit-6 and Bit-5: These bits denote the AH number as per the following table:

Table 2: SIM Bit-6 & Bit-5

Bit-6	Bit-5	AH number
0	0	AH0
0	1	AH1
1	0	AH2
1	1	AH3

iii. Bit-4 and Bit-3: These bits denote the Serv 2 supply requirements as:

Table 3: SIM Bit-4 & Bit-3

Bit-4	Bit-3	Supply required
0	0	No Supply required
0	1	Honey dew (H)
1	0	Leaves (L)
1	1	Wood (W)

iv. Bit-2 and Bit-1: These bits denote the Serv 1 Supply requirements as:

Table 4: SIM Bit-2 & Bit-1

Bit-2	Bit-1	Supply required
0	0	No Supply required
0	1	Honey dew (H)
1	0	Leaves (L)
1	1	Wood (W)

v. Bit-0: If this bit is "1", it denotes TR is required at the AH. Otherwise, TR is not required.

vi. Thus, for example, an ArUco marker with ArUco ID as 5 denotes AH0 as RAH with a TR requirement. Here, **Serv 1 requirements is Leaves and thus Serv 2 requirements becomes TR**. Here, ArUco ID 5 is 0x05 in Hex value which in binary is 0x05 = 0000 0101 and is depicted in the bit Table below:

Table 5: Example SIM bit-wise

ArUco ID Bits							
7	6	5	4	3	2	1	0
QAH Bit	AH Bit 1	AH Bit 0	Serv 2 Bit 1	Serv 2 Bit 0	Serv 1 Bit 1	Serv 1 Bit 0	TR Bit
0	0	0	0	0	1	0	1

vii. Elaborating the above example further, the AB is supposed to pick the Green Block from the Shrubs Area. The Green Block is then to be deposited in the Ant Hill 0's Service Location 1. Also, the Yellow Block depicting Trash is to be picked from Ant Hill 0's Service Location 2 and deposited in Trash Deposition Zone. The order of performing the task (providing Supply or removing Trash) is to be decided by the team as best suited by them to maximize the points and minimize the time for completing the task.

viii. A list of possible SIM combinations is available at this link: Possible ArUco IDs.

**SIM Placement Document:** A one-page A4 size document *"SIM Placement Document.pdf"* is shared in Task 2 folder containing 4 ArUco Markers and information of their designated SIM locations. The teams will have to print this document (as per the instructions in Task 2) and cut out the ArUco Markers and place them at the designated SIM locations. A Sample SIM Placement Document will look as follows:

SIM 0

SIM1
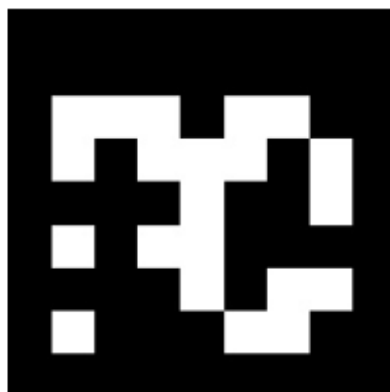
SIM 3

SIM 2

Figure 2: Sample SIM Placement Document

Thus, for such a SIM Placement Document, teams will print the document and place SIM 0 at SIM location associated with AH0, SIM 1 at SIM location associated with AH 1 and so on.

Supply Placement Table: Shrubs Area (SA) contains different supplies (each kind of supply represented by a specific coloured block as explained previously) placed from S1 to S6. This placement is defined by Supply Placement Table. An example Supply Placement Table is as follows:

Table 7: Supply Placement Table

S1	S2	S3	S4	S5	S6
BB	RB	BB	GB	RB	GB

Thus, for such a Supply Placement Table, teams will have to place Blue Block at Supply 1 (S1) location, Red Block at S2 and so on as per the table.

Trash Placement Table: This table defines the placement of Trash (Yellow Block (YB)) if the YB is to be placed at Serv 1 or Serv 2 for various Ant Hill. An example Trash Placement Table is as follows:

Table 8: Trash Placement Table

AH number	Trash Placement
AH0	Serv 2
AH1	No Trash
AH2	Serv 2
AH3	No Trash

Thus, for such a Trash Placement Table, teams will have to place Yellow Block (YB) depicting Trash at Serv 1 of AH1 and Serv 2 of AH2.

Note: SIM Placement Document, Supply Placement Table and Trash Placement Table mentioned above are examples considered for explanation and will be different during the competition.

In summary, each team builds Ant Bot (AB) with the following features:

- AB is equipped with White Line Sensors to follow a Path. AB begins from **Start** to reach different AHs.

- AB has a PiCam using which it identifies the SIM which contains information such as the Ant Hill (AH) number, AH type and Service requirements. After identification, it prompts the ArUco ID on the command prompt/terminal. Details are provided in Section 8.

- AB is required to have a pick and place mechanism to pick up Supplies from Shrubs Area and deposit as required in an AH. It identifies the type of Supply using the PiCam and after identification, it glows the corresponding colour in the RGB-LED mounted on it and then picks it up (if required). Details are provided in Section 8.

- AB deposits Supplies at designated Service Location 1 or Service Location 2 and also picks up Trash (T) from AH having Trash Removal (TR) as Service requirement and deposits the Trash in Trash Deposition Zone.

- AB reaches out to different AH to provide various Service requirements of each AH and after providing services to all the AH, it returns to **Start** position

- In the end, it turns ON the buzzer for 5 seconds to denote that the task is complete.

- The Queen Ant Hill (QAH) is the highest priority AH and should be serviced first to get a **Queen Ant Hill Bonus**. Details are provided in Section 8.

4. Arena:

Each team has to prepare the Arena. Preparing the Arena consists of four major steps:

1. Printing the arena design on flex sheet.
2. Constructing blocks for Supplies and Trash.
3. Constructing and placing AH Walls
4. Placing the SIM and blocks for Supplies and Trash.

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

4.1. Printing the arena on flex design:

Flex Design is shown in Figure 2. A Portable Document Format (.pdf) file containing the flex design is provided to the teams in Task 2. Each team prints the flex design according to the directions given in the *"Read Me.pdf"* file of Task 2 folder.

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" the 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 lead to a fire hazard. Please maintain the Arena in good condition. If the Arena is found damaged or in a condition that is not good enough to properly evaluate the team, e-Yantra has the right to disqualify the team. **The final decision is at the discretion of e-Yantra.**
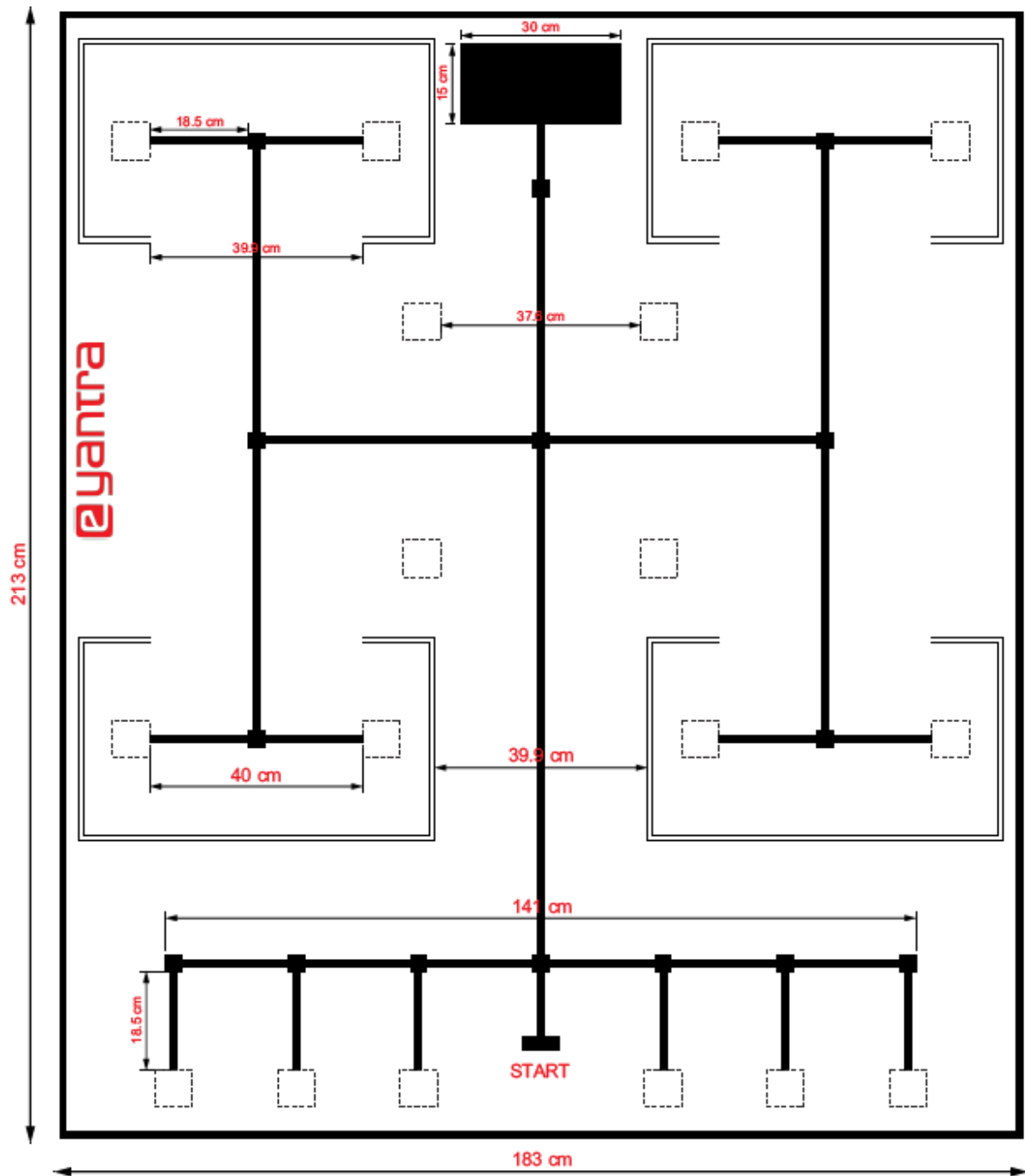
Figure 3: Arena with Dimensions

The Dimension of the arena are as shown in figure 3:

- **Dimension of flex sheet:** 183 cm x 213 cm

- **Line width (Path width):** 1.2 cm

- **Node Dimension:** 3cm x 3 cm

Each of the area marked for placing SIM, Supply/Trash blocks is of the dimensions: 7cm x 7cm.

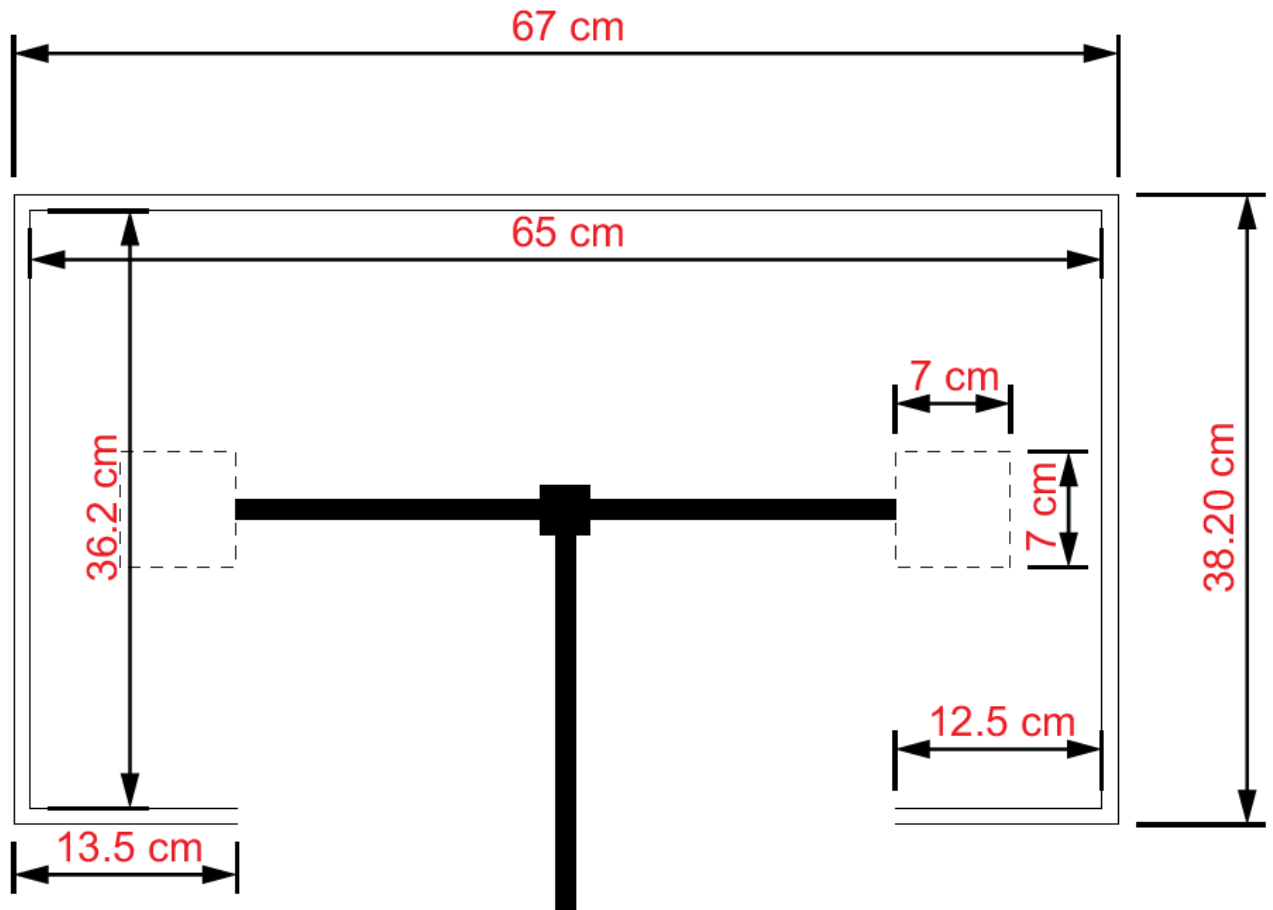The Ant Hill dimensions are as shown in figure 4 below:

Figure 4: Ant Hill Dimensions

4.2. Preparing the blocks for Supplies and Trash:

Materials required and instructions for preparing the blocks:

- Thermocol sheets.
- Red, Green, Blue and Yellow colour chart paper.
- Reference soft copies of Red, Green, Blue and Yellow chart papers are given in *"Color_Chart_Paper.pdf"* which is provided in Task-2. Print this file as per instructions in *"Read Me.pdf"* file received in Task 2 folder.
- Dimension of each Supply and Trash block is 6cm x 6cm x 6cm. Each team prepares blocks of respective dimension using Thermocol sheets.
- Team prepares 2 quantities of Supplies each of Red (R), Green (G), and Blue (B) and 2 quantities of Trash, Yellow (Y) by covering the Thermocol blocks with respective coloured chart paper. (You can prepare additional/extra blocks as required considering that blocks may get damaged during practice) A Red (R) Supply is shown as an example in Figure 5.
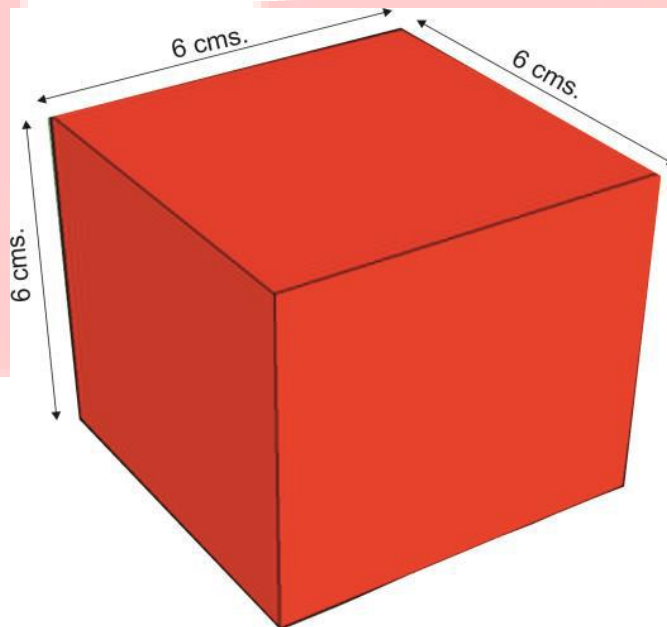

Figure 5: Red Supply

4.3. Constructing and placing AH Walls:

Materials required for preparing the walls:

- Thermocol sheets
- Double Sided Tapes/Adhesives

For each AH, thermocol sheets are to be cut in dimensions

- One sheet: 67cm X 1cm X 20cm
- Two Sheets: 37.2cm X 1cm X 20cm
- Two Sheets: 12.5cm X 1cm X 20 cm

These thermocol sheet cuttings are to be fixed to flex using double sided tape or any other appropriate adhesive at the AH boundary as shown below.
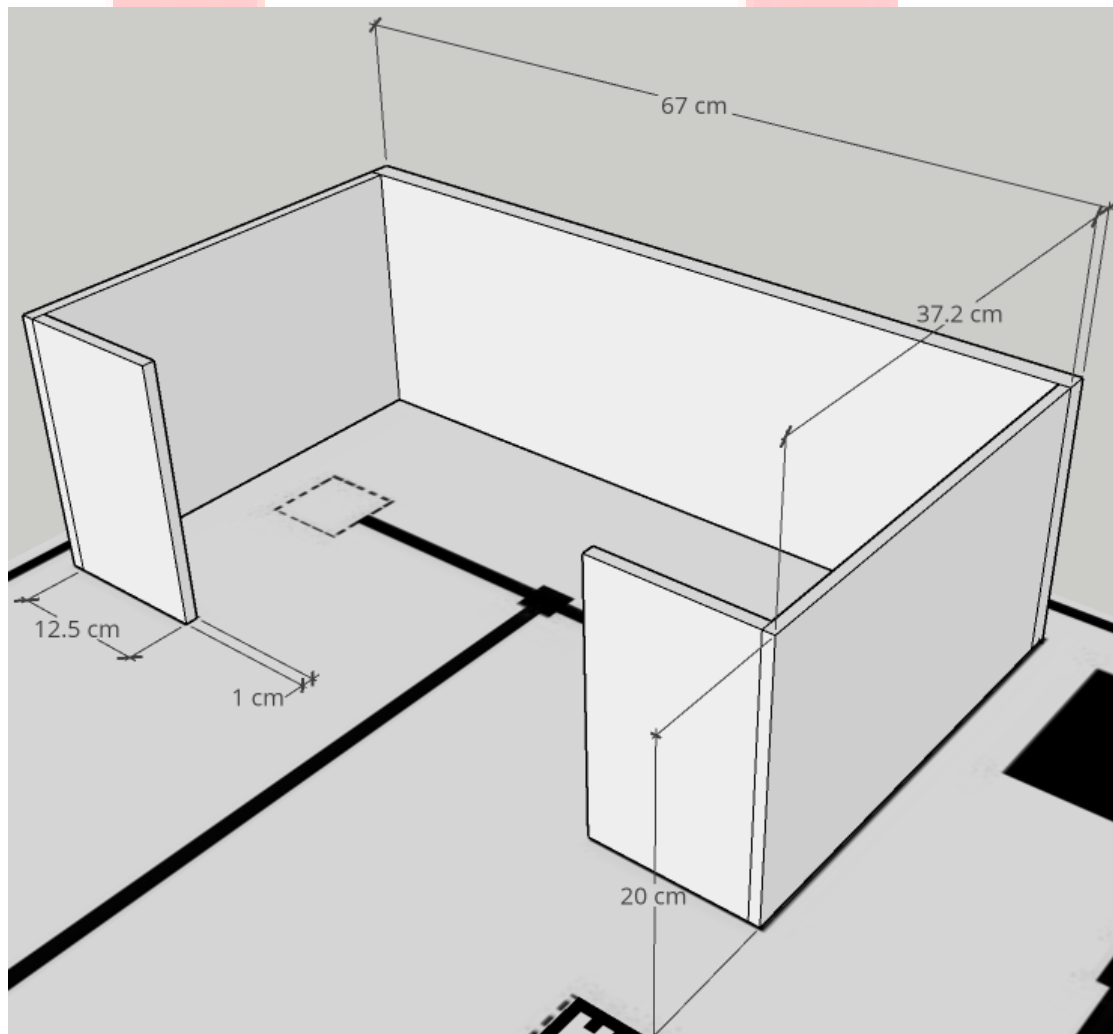

Figure 6: Sample AH Wall placement with dimensions

4.4. Placing the SIM and blocks for Supplies and Trash:

Placement of SIM and blocks for Supplies and Trash are defined in SIM Placement Document, Supply Placement Table and Trash Placement Table as discussed in Section 3.

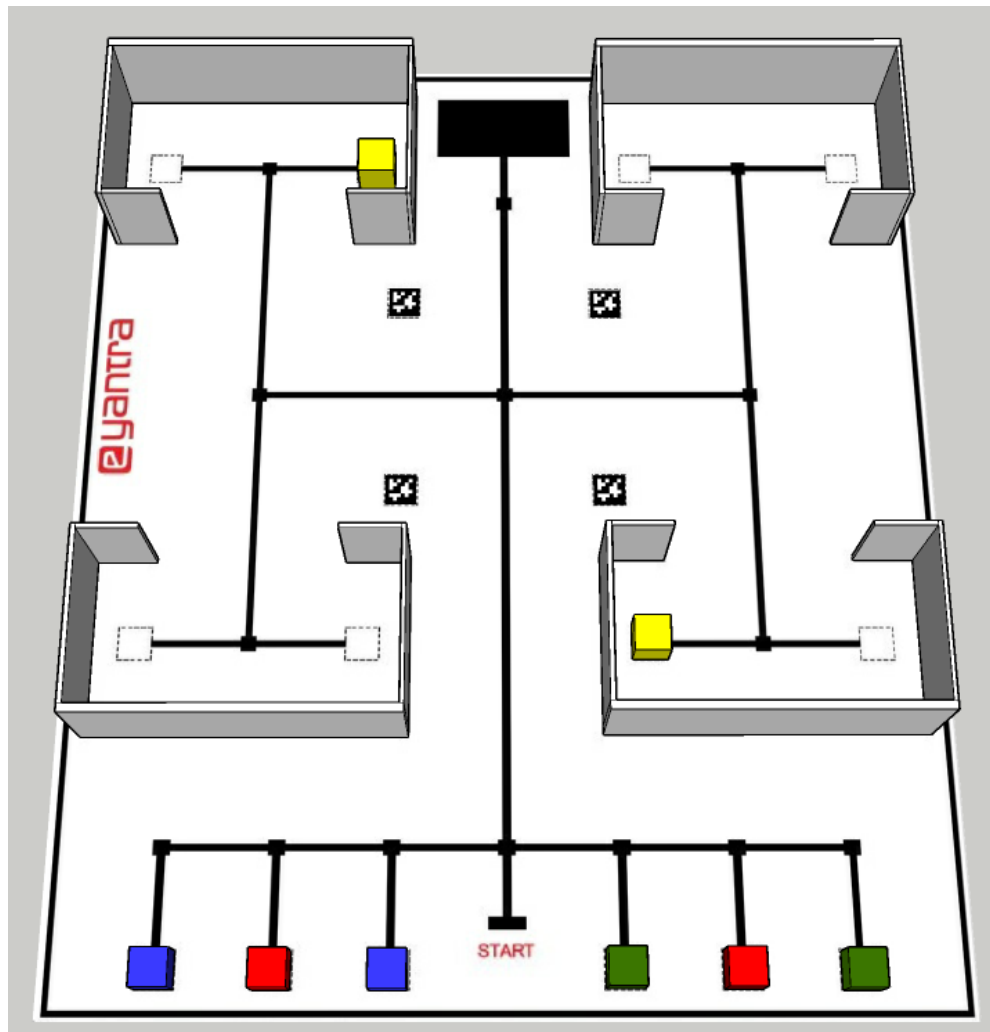After placing SIMs, AH Walls and blocks for Supply & Trash, the arena will look as shown in Figure 6:

Figure 7: Sample Arena Setup

Note: The arena shown in Figure 7 is specific to the example SIM Placement Document, Supply Placement Table and Trash Placement Table considered in Section 3. During the competition the arena setup will be different as per the tables/document provided at that time.

5. Hardware Specifications:

5.1. Use of Raspberry Pi and Arduino Nano:

All participating teams must use only the Raspberry Pi and Arduino Nano sent to them in the kit. Only one Raspberry Pi and Arduino Nano is allowed per team. The Ant Bot assembled by the teams should be completely autonomous.

5.2. Use of other components provided in the kit:

Along with the Raspberry Pi and Arduino Nano, teams will receive White Line Sensors, PiCam, a 16GB memory card, Intex 6000 mAh Power Bank, Battery, DC Motors, Servo Motors, Motor Driver circuit, L clamps and Wheels.

5.3. Use of components NOT provided in the kit (These may be additionally purchased and used by teams as required)

- Teams will have to design their own chassis for building the Ant Bot and stand for PiCam. Please be careful while deciding the dimensions for the chassis because AB is not allowed to touch or displace the AH Walls and/or traverse over, touch, damage or displace the SIM placed on the Arena. Doing so will incur penalty as explained in Section 8.

- Discrete additional components like Resistors, Capacitors, Jumper wires etc. may be used

- Additional wheels, shafts, L clamps etc. may be used

- Teams may connect external actuators **(only after getting permission from e-Yantra reviewer)** along with their driver circuits to the Ant Bot only on the condition that the actuators must be controlled through the Raspberry Pi or Arduino Nano present on the Ant Bot.

- The teams are not allowed to use any other sensors apart from those provided in the kit.

- Teams are not allowed to use any other Power source for the Ant Bot apart from the Battery/Power Bank provided in the kit and/or any other component to build the Ant Bot apart from those mentioned above.

6.   Software Specifications:

6.1. You can use OpenCV 3.4.2, Python 3, Arduino IDE, Numpy, Scipy, Matplotlib, Imutils, PIL, OpenGL etc.

6.2. Use of any non-open source software is not allowed and will result in disqualification of the team.

6.3. As per e-Yantra policy, all your code and documents are open source and may be published on the e-Yantra website.

7. Theme Rules:

7.1. The maximum time allotted to complete the task is 10 minutes in per Run. A maximum of two Runs will be given to a team. The best of two scores from the two Runs will be considered as the team's final score. A maximum of two repositions will be allowed in each Run (as explained in further points).

7.2. The team must use OpenCV-3.4.2, Arduino IDE and libraries and Python 3 primarily for the task. However, in addition to these softwares, participants may use compatible open source libraries and software utilities, provided they are indicated and disclosed clearly to the e-Yantra Team.

7.3. To communicate between the computer and the robot, teams have to setup the WiFi network as explained in Hardware testing documents. In finals at IIT-Bombay, WiFi network will be provided by e-Yantra.

7.4. At the start of a Run, AB should be switched ON and placed at the "Start" position in the arena facing the AHs.

7.5. The team should start the execution of code when told to do so by the e-Yantra reviewer. This is the start of a Run. The timer will start at the same time.

7.6. Once the robot is switched ON, intervention by any participant or team is NOT allowed.

7.7. Any human intervention is considered as reposition (a reposition can be done by e-Yantra team member only on the request of the participant and approval of the e-Yantra reviewers / judges). Rules for reposition are explained in further points.

7.8. A Run ends and the timer is stopped if any of the following conditions is satisfied:

- The AB completes the task and turns ON the buzzer at "Start" position for 5 seconds.
- The maximum time limit (600 seconds) for completing the task is reached.
- The team needs repositioning but has used maximum allowed repositioning options of that Run.

Note: Marks will be calculated on the basis of the state of Run which is governed by all the elements mentioned in Scoring Formula

7.9. Second Run starts after resetting the score, timer and Arena. The score of both Runs is recorded and best of the two Runs is considered as the team's final score.

7.10. For the second Run, teams are not allowed to make any software changes. However, hardware changes are allowed with the approval of e-Yantra reviewer.

7.11. Participants are not allowed to keep anything inside the Arena other than AB.

7.12. The time measured by the e-Yantra reviewer is final and will be used for scoring the Teams.

7.13. Time measured by any participant or team by any other means is not acceptable for scoring.

7.14. AB is not allowed to make any marks on the arena, while traversing the Arena. If AB is found damaging the Arena, it will be immediately stopped; repositioning will be allowed as per the rules. **The final decision is at the discretion of the e-Yantra reviewers / judges.**

7.15. Reposition rules:

- While traversing the Arena, if AB strays off the Path, a member of the e-Yantra team will place the AB on the previous Node which was traversed properly, only on the request of the team and approval of the e-Yantra reviewer (Refer figure below):
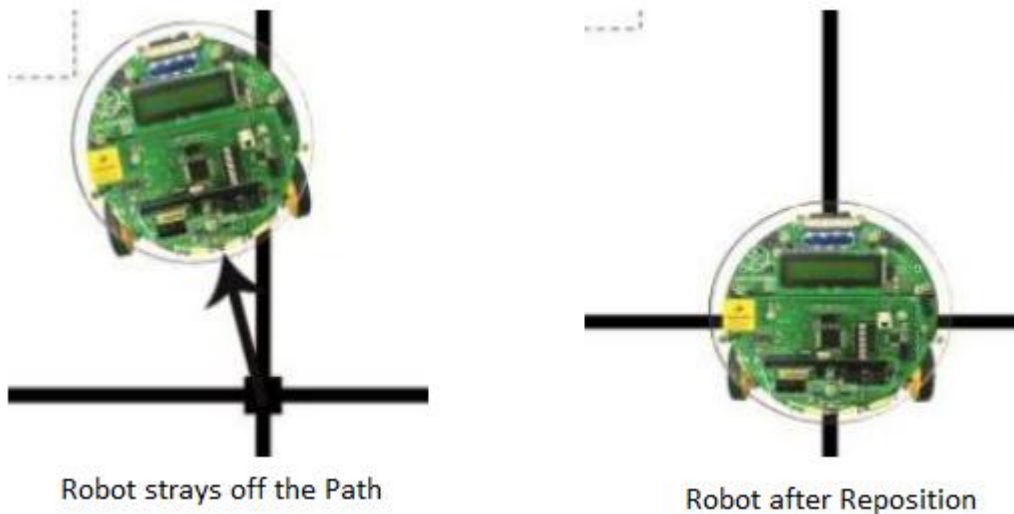

Robot strays off the Path   Robot after Reposition

Figure 7: Repositioning

- During Reposition, the timer will not stop and AB will not be switched off.
- **Teams are allowed a maximum of two repositions in every Run**. The Run ends and timer is stopped if AB requires a reposition after both repositions have already been used.

8.   Judging and Scoring System:

The Run time starts as soon as the robot is switched on and the time will end when the robot completes the task or Run ends.

The final score of the team will be the best score of the two Runs.

The team's total score will be calculated by the following formula -

Total Score=(600-T) + (30*CSD) + (30*CSI) + (75*CSEP) + (75*CSED) + (100*QB) +

(300*OB) + (DB) - (50*P)

Where:

T = Total Time

Total time is the time taken in seconds to complete the task or end of Run

CSD = Correct SIM Detection (30 Points)

Team gets 1 CSD point when the correct **Service and Identification Marker (SIM)** i.e. Aruco marker is detected and its correct ID (in decimal number system) is displayed/prompted on command prompt/terminal with message: "ID Detected: #ID".

For example, if ID detected is 25, message should be prompted as: "ID Detected: 25".

CSI = Correct Service Identification (30 Points)

Team gets 1 CSI point when the correct Service (Supply/Trash) is identified by detecting the correct colour of the Service block (Red/Green/Blue/Yellow). This is indicated by turning ON RGB LED for 1 second and then turning it OFF with glowing corresponding colour i.e. Red colour for Honeydew, Green Colour for Leaves and Blue colour for Wood. For Trash, both Red and Green LED are to be turned ON simultaneously for 1 second and then turned OFF.

CSEP = Correct Service Execution Pick (75 Points)

Team gets 1 CSEP point when the identified Service block (Supply/Trash) is picked up.

CSED = Correct Service Execution Drop (75 Points)

Team gets 1 CSED point when the identified Service block (Supply/Trash) is dropped in the correct deposition region marked for that particular Service.

The possible correct and incorrect Service Execution Drops are depicted in the figure below:
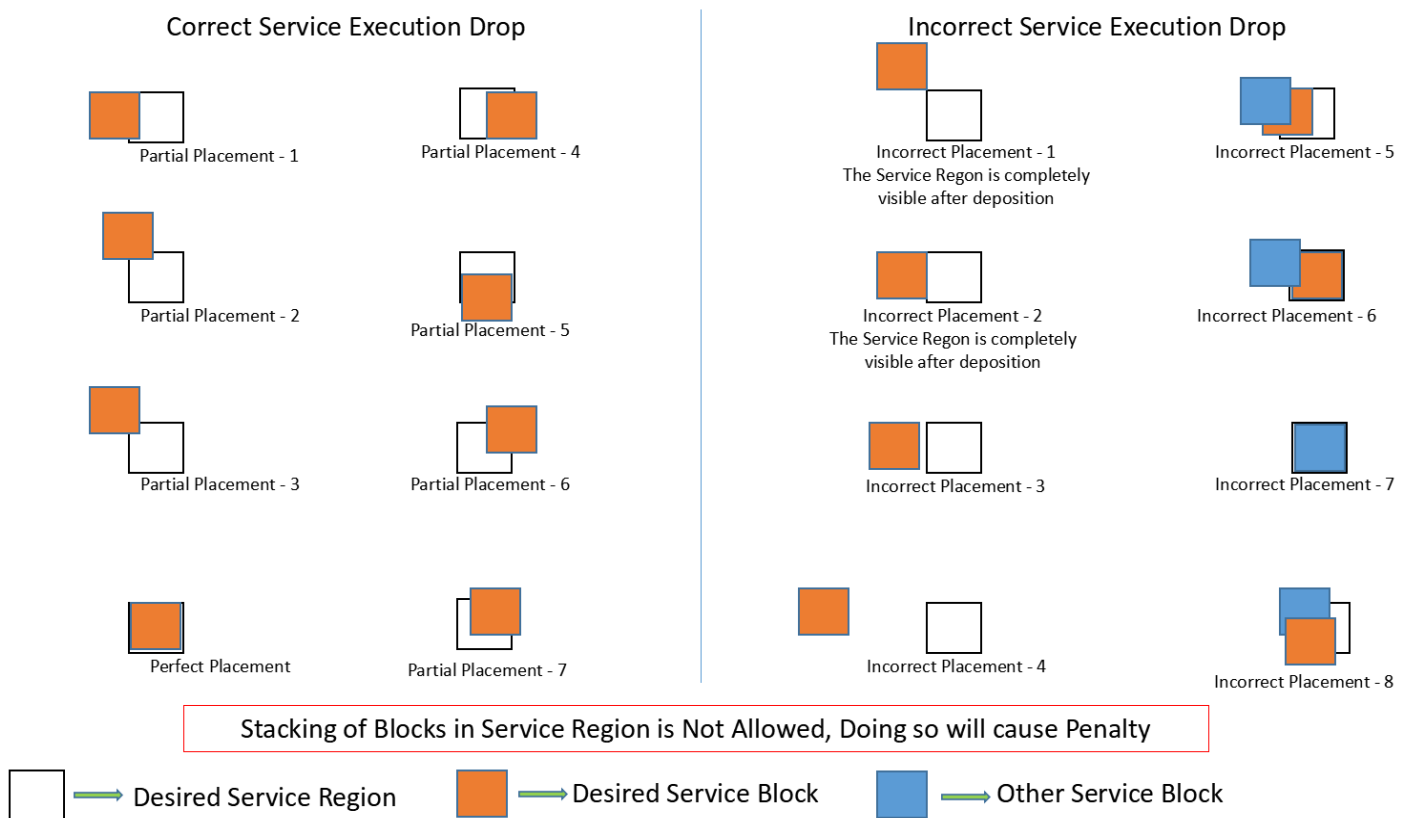

Figure 8: Service block Drop rules

QB = Bonus for servicing Queen Ant Hill (QAH) (100 Points)

If QAH is served first before other AHs, the Team will get 1 QB bonus point. There will be a maximum of 1 QAH on the Arena. If there is no QAH on the Arena, this Bonus will not be considered in the score.

OB = Overall Bonus (300 Points)

If the Team completes the task with no penalties and having Serviced QAH first (if QAH is present), then the Team will earn 1 bonus point as an Overall Bonus

DB= Design Bonus (300 Points)

Teams will get Design Bonus points ranging from 0 to 300 based on their robot structure and design aspects and design of pick and place mechanism.

P = Penalty (50 Points)

The cases when penalty will be levied are discussed in the below.

Penalty Cases -

For every Penalty, 50 points will be deducted from the Total Score

Penalties will occur for the following cases -

- **Reposition**: For each Run, a team is allowed a maximum of 2 repositions. More than 2 repositions will result in end of Run. Each reposition will attract one Penalty point i.e. 50 points will be deducted from Total Score for each reposition.
- **Hitting AH Wall**: If the AB hits or touches the Ant Hill Wall, it will result in a penalty.
- **Contact with Other Service Blocks**: If the AB makes unnecessary contact with Service blocks other than the one it is Picking or Dropping, it will result in penalty. This penalty includes displacing other Service blocks and these displaced blocks will not be returned to original position until the Run ends.
- **Service and Identification Marker (SIM) Damage** i.e. Aruco marker damage: If the AB traverses over, touches, damages or displaces the Aruco marker placed on the Arena, it will result in a Penalty.
- **Stacking Blocks**: If the AB stacks Service blocks (including Trash) one above another, there will be a penalty counted per block in the stack. This includes even if the last block in the stack is the correct or desired one; no points will be given and a penalty will be counted. Stacking of blocks in **NOT** allowed.