2025 International Intelligent RoboSports Cup

RoboSot : Mobile Robot Manipulator Challenge

Abstract

Mobile robotic arms demonstrate high flexibility in automated factories, enabling intelligent collaboration with humans to provide a safer and more efficient working environment. In addition to the overall performance assessment in the main competition, this contest includes two sub-competitions that separately evaluate the various capabilities of the mobile platform and the robotic arm. Overall, a mobile robotic arm must possess abilities such as line following, image recognition, cargo handling, and autonomous movement. Furthermore, to simulate the ever-changing environment of factories, the cargo transport and unloading locations will be randomly assigned, presenting a more realistic and challenging task for the mobile robotic arm.
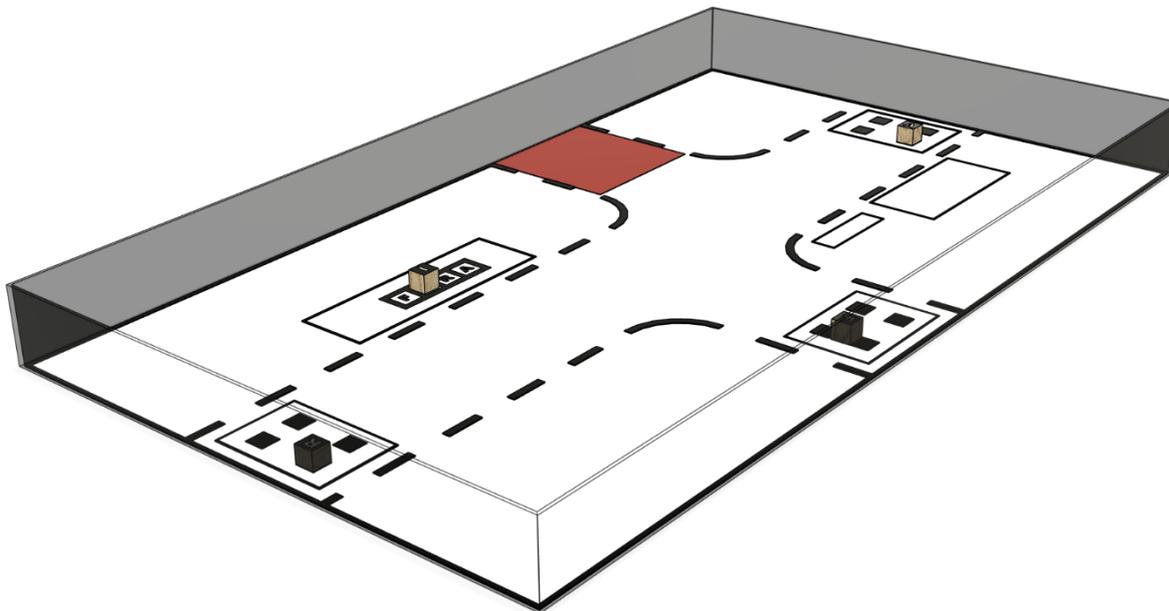

Figure 1.Field simulation diagram

1. Robot Requirements

1.1 Teams must design a mobile manipulator, consisting of a mobile platform and robotic arm— referred to as the "robot."

1.2 The robot must be no larger than 35cm × 35cm × 50cm. A measuring box will be used to verify dimensions before the competition.

1.3 After the competition begins, robots may extend their components but must not leave any parts behind on the field.

1.4 Robots may be built from any material, but use of high-pressure gas, explosives, or hazardous elements is prohibited. Small pneumatic pumps are allowed.

1.5 Robots must operate fully autonomously. No remote control or external influence is allowed.

1.6 No external power, data, or network cables may be connected during the event.

1.7 Once inspection is complete, no software changes are permitted, including remote access to the robot.

2. Robot Inspection

2.1 During the designated inspection time, teams must bring their robots to the inspection area for dimension verification and compliance checks. Any robot that does not pass must be modified and re-inspected within the inspection period. Once inspection is complete, no further modifications (hardware or software) are allowed. Failure to pass inspection within the allotted time will result in disqualification for that round.

2.2 Each robot must pass inspection before every competition attempt. Outside of official competition or inspection periods, teams may perform repairs—but may not retrieve the robot before all teams have completed the current round.

3. Competition Preparation

3.1 Before each team begins, there is a one-minute preparation period following staff instructions. During this time, robots may be powered on or checked—but no program changes or mechanism deployments are allowed.

3.2 At the end of the minute, the robot must be placed in the starting area. Do not touch the robot without permission.

3.3 If the robot moves out of the start zone before the official start, the referee may instruct the participant to move it back.

4. Competition Events Overview

The competition includes a Overall Competition and two Sub-Competitions. Each will have distinct field specifications, rules, and scoring methods.

5. Overall Competition

5.1 Overall Competition: Field Specifications

5.11 As shown in Figure 2, the competition field is roughly divided into five areas: the starting area, the drop-off area and three cargo collection areas. The dimensions of the field are 260 cm by 149 cm (with a 1 cm wide outer boundary line). For more details, see Figure 3.

5.12 The roads on the field are 38 cm wide. Both sides of the road are marked with black dashed lines, with each dash and the gap between dashes measuring 10 cm in length and 2 cm in width. (The length of the dashed lines near the edge of the map will be indicated separately in Figure 3.) The field will include walls with a height of 20 cm.

5.13 Start Area (Area A) – A red square area of 38 cm × 38 cm where the robot begins.

5.14 Drop-off Area (Area B) – A checkered area where cargo is delivered. Its inner dimensions are 60 cm × 18 cm (with a 5 mm border). Inside this drop-off area, a cargo placement area (30 cm × 9 cm, as shown in Figure 3) will be placed at a random location.

5.15 As shown in Figure 4, the cargo placement area is marked with letters identical in font to those on the blocks, and each side of this marked target area is 5 mm larger than a block (i.e. 55 mm × 55 mm) to accommodate the block.

5.16 Cargo Collection Areas (Areas C, D, E) – Three areas where cargo (blocks) are initially placed. Each cargo collection area's inner dimensions are 29.7 cm × 21.0 cm (equivalent to A4 paper size, with a 5 mm border). Each cargo collection area contains four possible positions for blocks,

totaling 12 possible block positions across all three areas. A cargo collection area may be elevated to one of several heights (detailed later).

5.17 Cargo Blocks – Each cargo piece is a wooden cube of 5 cm × 5 cm × 5 cm. Each block has one face labeled with one of the letters "F", "I", "R", or "A" (white letter on black background). The labeled face is oriented facing up, aligned according to the reference layout. The labels are printed on thick paper and affixed to the block's surface using a low-gloss (non-reflective) material.

5.18 The field's colors and materials are chosen to minimize any impact on the robot's sensors or performance, expecting the robot to adapt to minor variations in the environment. The actual field may have slight color differences or up to ±1 cm dimensional deviation.
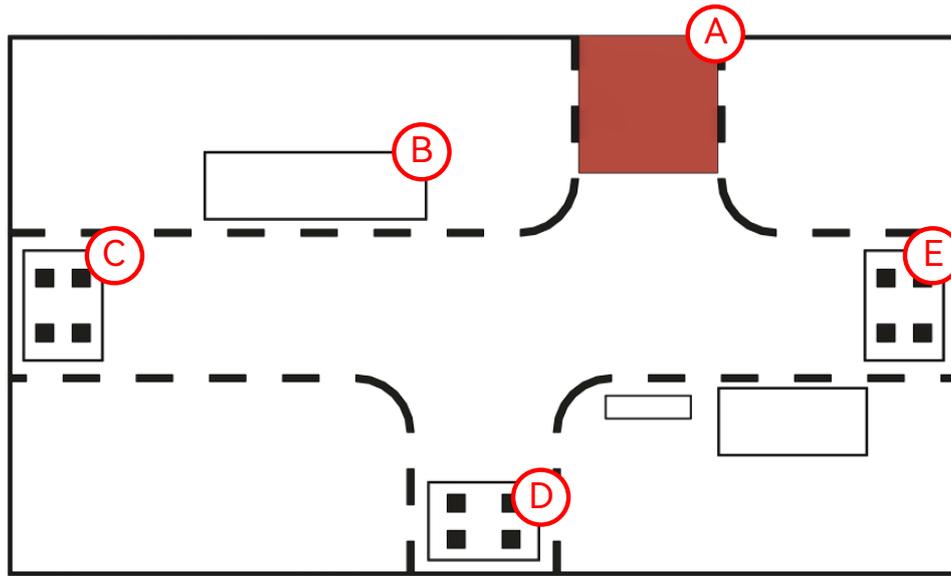

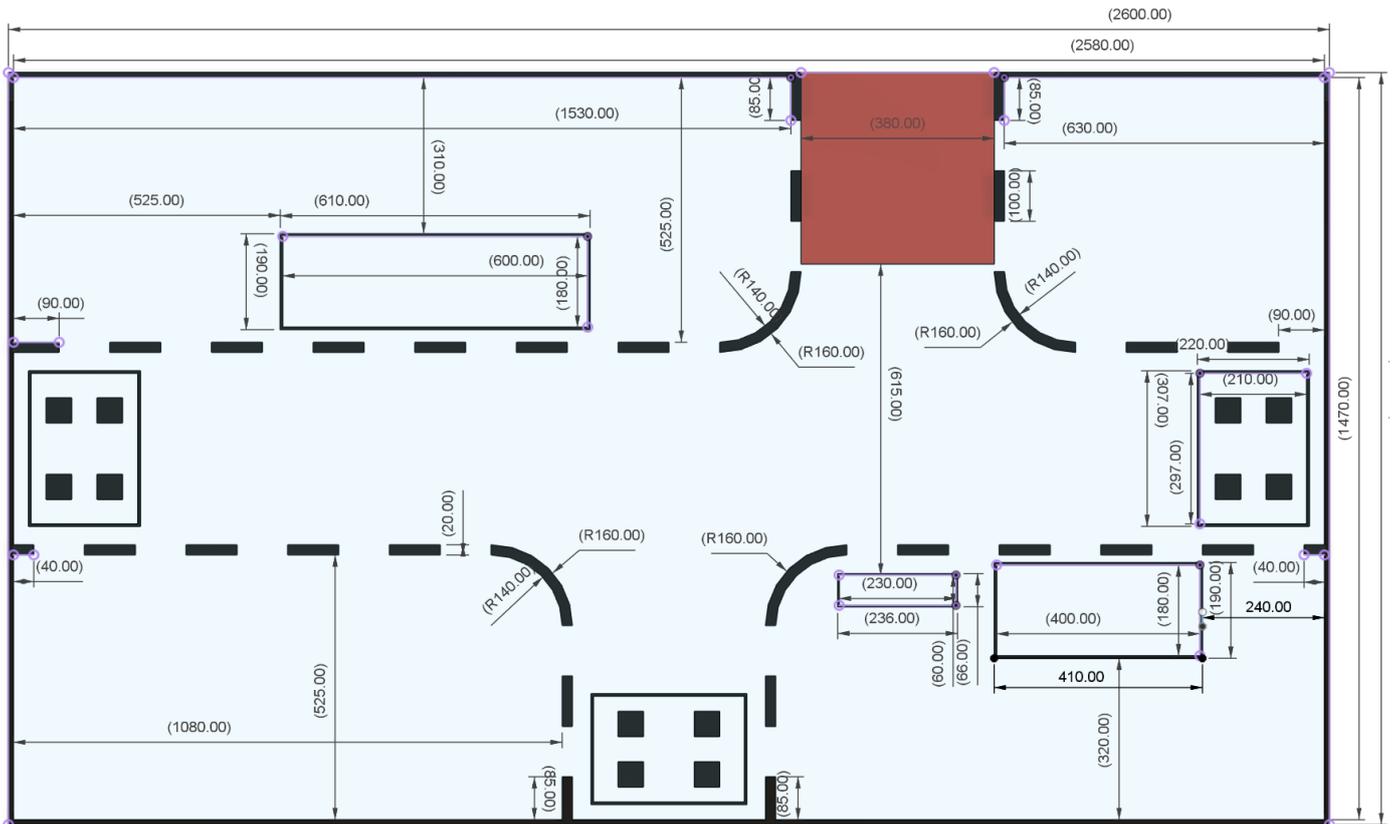Figure 2. Overview Diagram of the Overall Competition Field

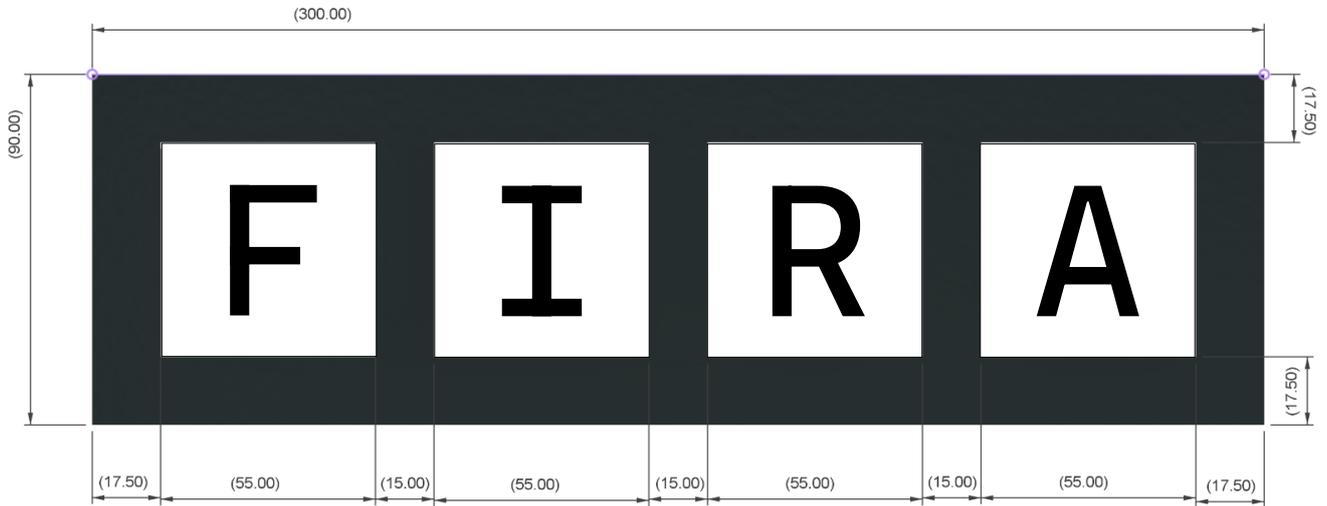Figure 3. Overall Competition Field Dimensions (Unit: mm)

Figure 4. Dimensions of the Cargo Placement Area(Unit: mm)

5.2 Overall Competition: Contest Rules

In the Overall Competition, the objective is for the robot to place four labeled wooden blocks ('F', 'I', 'R', 'A') into designated cargo placement positions. Each of the three cargo collection areas can be set to one of three heights (0 cm, 4 cm, or 8 cm); the heights may repeat among the areas. The initial placement of each of the four blocks (one block in each cargo collection area) is determined by a random draw. The height of each cargo collection area and the position of the cargo placement area within the drop-off zone are randomly set by the referees before the match.

Within a 5-minute match, the robot must autonomously travel along the black dashed-line paths on the field to the cargo collection areas, pick up the blocks, and place them onto the cargo placement area in the drop-off zone (Area B) matching the corresponding letter. After delivering all blocks, the robot must return to the start area. Completing all tasks within the time limit constitutes finishing the challenge. Each team has two attempts to perform the Overall Competition task.

5.3 Overall Competition: Lot Drawing and Field Inspection

5.31 After the preparation period and before the match begins, the team draws lots as instructed to determine the initial positions of the four blocks.

5.32 The referees will randomly determine the height of each cargo collection area (0 cm, 4 cm, or 8 cm) and the location of the cargo placement area within the drop-off area. The cargo placement area will not be rotated when placed (only its position changes). These settings (block positions, area heights, placement location) are reset for each team's match.

5.33 Once the referees have placed all blocks and set up the field, teams may inspect the block positions and other field elements. Any objections must be raised immediately to the referees before the match starts. No objections will be accepted after the match begins.

No elevation (0 cm height)   Elevation height: 4 cm   Elevation height: 8 cm
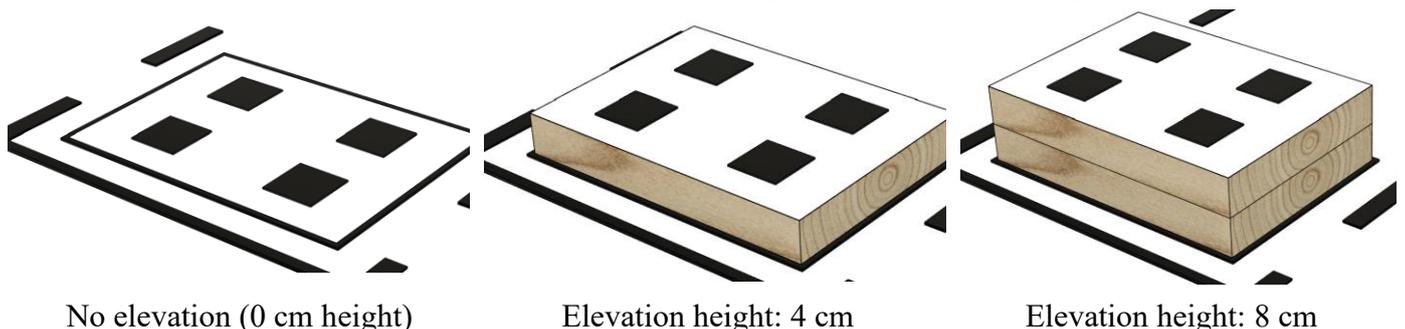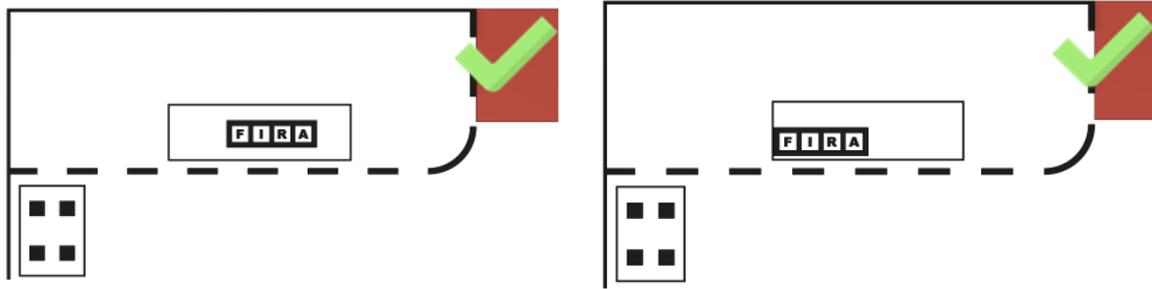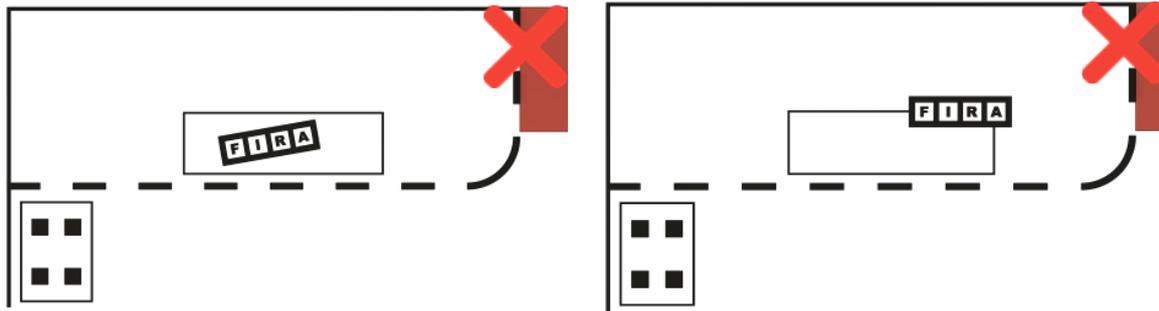
Figure 5. Schematic Diagram of the Cargo Collection Area Height

Possible Placement Scenarios (Inside the frame, Aligned with the frame edge)

Invalid Scenarios (Placed at an angle, Placed beyond the boundary of the drop-off area)

Figure 6. Placement Diagram of the Cargo Placement Area

5.4 Overall Competition: Match Start

5.41 Before the match starts, the robot must remain entirely within the red start area (Area A).

5.42 The match begins on the referee's whistle. Each team is allowed up to two restarts within the 5-minute match. To restart, the robot must be brought back to the start area, all blocks must be returned to their original starting positions, and the robot must continue to meet all check-in requirements. Restarts require referee approval, and the match clock continues to run during the reset process.

5.43 The competition will be run according to these official rules. For any situations not explicitly covered, the referees have the final authority for interpretation and decision.

5.44 The competition environment is not controlled for perfection; field lighting and other external factors are part of the challenges the robot must overcome. However, the use of devices such as camera flashes by bystanders, which could interfere with the robot, is prohibited during the match.

5.45 Each teams must equip the robot with a physical start activation mechanism (such as a start button). Upon the referee's signal to begin, a team member must press the button to start the robot. Remote methods of starting the robot are not allowed.

5.46 Once the match has started, if the robot malfunctions or is damaged, the clock will continue to run.

5.47 If at any time a team needs to reposition the robot to the start area or reset the blocks to their initial positions (for a restart), they must obtain referee approval. If team members touch the field or the robot without permission, the referee may deduct 10 points from that team's score for the match, unless the intervention was to prevent the robot from falling off the field.

5.48 After the robot completes the task, the team must promptly notify the referee to stop the timer. If the referee delays stopping the clock due to uncertainty about task completion, the team may not dispute the timing.

5.49 Each match has a maximum duration of 5 minutes. If a team does not complete all tasks, the match time will be recorded as 5 minutes. Teams may choose to end the match early, but the official recorded time will still be 5 minutes.

5.5 Overall Competition: Scoring

5.51 Each team competes twice in the Overall Competition, and scoring is based on a points system.

5.52 Each match has a maximum score of 50 points: up to 40 points from block placement and up to 10 points from the robot's final position. The highest total score across both matches is 100 points.

5.53 Block Placement Scoring (maximum 40 points in total): See Table 1 below. For each block:

- If the block is placed completely within the target area, 10 points.
- If over half of the block's area is inside the target area, 8 points.
- If the block is only partially (less than half) on the target area, 5 points.
- If the block is only delivered into the drop-off area (Area B) but not placed onto the target area, 2 points.
- If the block touches the boundary line of the drop-off area or the block is toppled (the labeled face is not facing up), 0 points.

5.54 The scoring method for the robot's final position is shown in Table 2. After completing the task, the robot must return to the starting area.

- If the robot fully enters the red area, 10 points.
- If more than half of the robot's area enters the starting area, 8 points.
- If only part of the robot (less than half) enters the starting area, 5 points.
- If the robot does not return to the starting area at all, it will not receive any points for this item.

Scoring is based on whether the robot's vertical projection (chassis footprint) is within the area. However, points for wooden blocks can still be earned regardless.

Table 1. Block placement scoring criteria.

Block Placement Condition	Points	Note
Block completely in target area	10	Each block is scored independently, and only the highest applicable score is counted for that block. For example, if all four blocks are more than half inside their target areas but none are completely inside, each block scores 8 points, for a total of 32 points.
Block over 1/2 in target area	8	
Block partially on target area (<1/2)	5	
Block only in drop-off area (not on target)	2	
Block touches boundary line or block toppled	0	

Table 2. Robot final position scoring criteria.

Robot Return Position	Points	Note
Robot entirely in start area	10	If the robot scores 0 points for the return position, but any points earned from block placements still count toward the total.
Robot > 1/2 in start area	8	
Robot partially (less than half) in start area	5	
Robot does not enter the area	0	

10 points	8 points	5 points
5 points	2 points	2 points
0 point	0 point	0 point
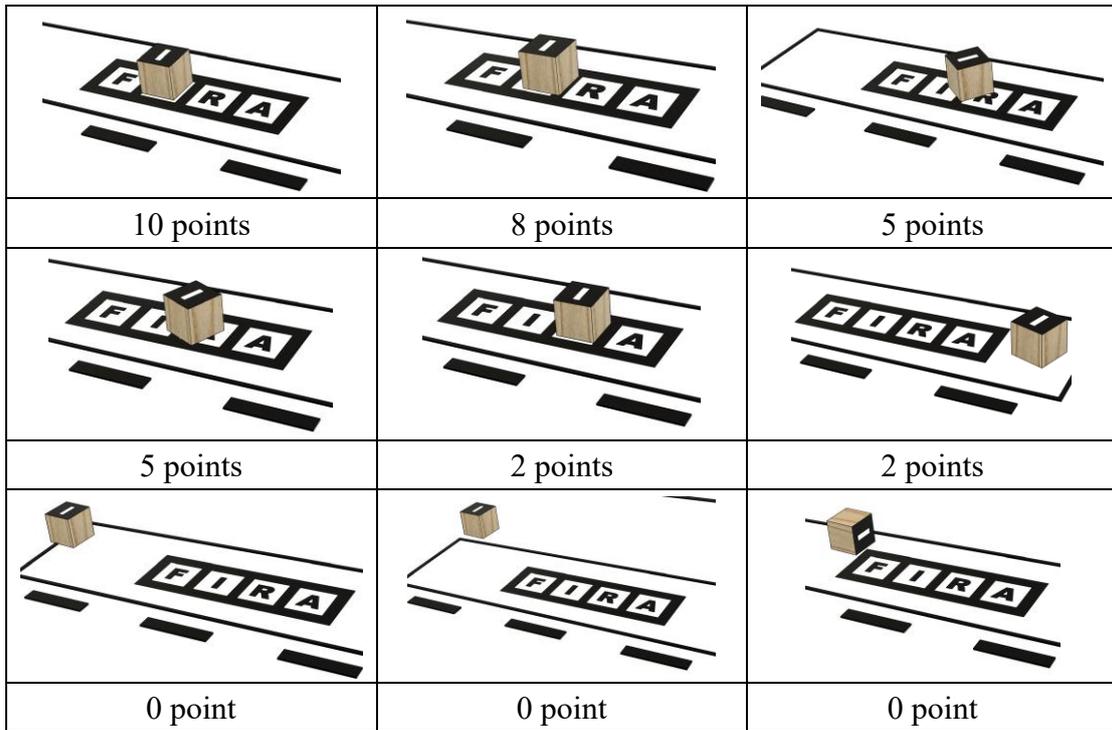
Figure 7. Scoring Illustration of Wooden Block Positions

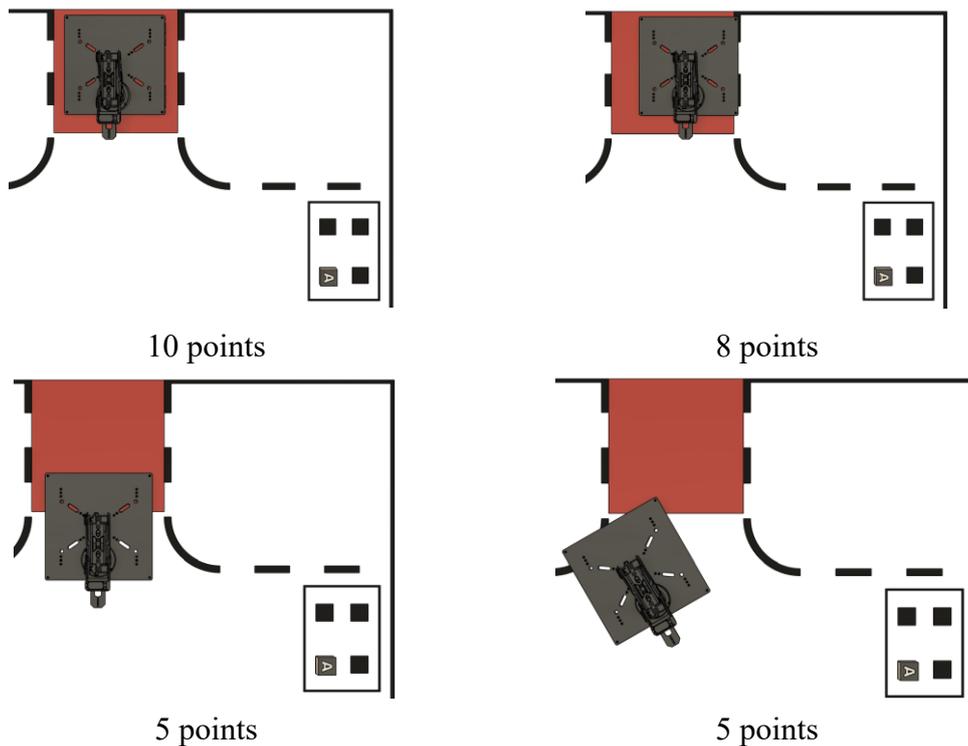|	
10 points	8 points
5 points	5 points

Figure 8. Scoring Illustration of Robot Positions

5.6 Overall Competition: Penalty Deductions

5.61 If the robot's chassis drives outside the black dashed-line road boundaries at any time, 5 points are deducted for each occurrence (being exactly on the line is not penalized).

5.62 If the robot's chassis collides with a wall, 5 points are deducted for each occurrence.

5.7 Overall Competition: Ranking Calculation

For the Overall Competition, each team's two match scores (out of 100 points total) will be summed. Teams are ranked by their total score. The top three teams with the highest totals will be awarded Overall Competition 1st Runner-up, and 2nd Runner-up, respectively. If teams are tied in total points, the team with the shorter completion time is ranked higher. If they are still tied, the team with the lighter robot is ranked higher.

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6. Sub-Competitions

The sub-competitions consist of two independent challenge events: the Autonomous Movement Challenge and the Smart Object Handling Challenge. The field specifications, field setup, and rules for each are described below.

7.1 Sub-Competitions- Autonomous Movement Challenge: Field Specifications

7.11 As shown in Figure 9, the field for the Autonomous Movement Challenge is divided into five areas: the start area, the signboard area, and three stopping areas. The field's outer dimensions are 260 cm × 160 cm. (The field layout and dimensions are the same as in the Overall Competition in Figure 3.)

7.12 Start Area (Area A) – A red square area of 38 cm × 38 cm where the robot starts.

7.13 Signboard Area (Area B) – An area marked for a signboard. The signboard area's inner dimensions are 23 cm × 6 cm (with a 3 mm border). A signboard (20 cm × 10 cm × 3 cm, on a base 23 cm × 6 cm × 2 cm) is placed 65 cm from the start area. The signboard displays three colored cards (yellow, green, blue), each 7.5 cm × 5 cm. The order of these color cards can be changed for each match. (See official specifications for the signboard and cards in Figure 10.)

7.14 Stopping Areas (Areas C, D, E) – Three designated stopping areas, each 38 cm × 38 cm, corresponding to the three colors on the signboard.

7.15 The field's colors and materials are chosen to not significantly affect the robot's performance, expecting the robot to adapt to the environment. The field materials may have slight color variations or up to ±1 cm deviation in dimensions.
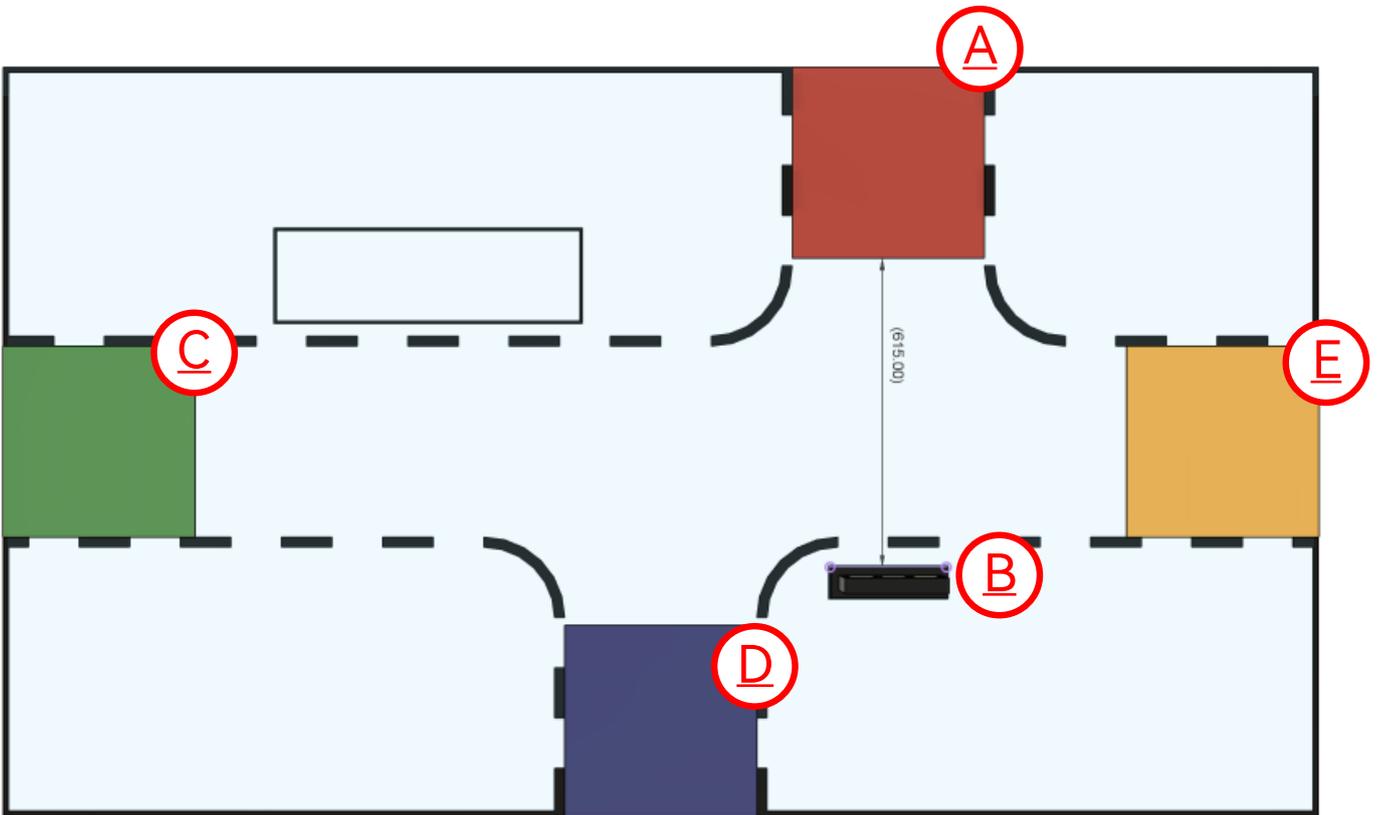
Figure 9. Schematic Diagram of the Autonomous Movement Challenge Field (Unit: mm)

Figure 10. Signboard Specification Diagram (Unit: mm)

7.2 Sub-Competitions- Autonomous Movement Challenge: Competition Rules

In this challenge, the robot must start from the start area (Area A) and move to the signboard (Area B) to read the sequence of colored cards. Based on the sequence of colors from left to right on the signboard, the robot must autonomously travel along the black dashed-line path to each corresponding colored area (C, D, E) in order, and stop in each for 3 seconds. Finally, the robot returns to the start area. Successfully visiting all specified areas in the correct order and returning to start within the time limit completes the task. The arrangement of the color cards is decided by drawing lots for each team. Each team has two attempts at this challenge.

7.3 Sub-Competitions- Autonomous Movement Challenge: Field Inspection

7.31 After the preparation period, each team draws lots to determine the order of the three color cards on the signboard. (The color order is reset before each team's match.)

7.32 Once the referees have placed the color cards according to the draw, teams may verify the card order and other field elements. Any objections must be raised immediately to the referees before the match starts. No objections will be accepted after the match begins.

7.4 Sub-Competitions- Autonomous Movement Challenge: Match Start

7.41 Before the match begins, the robot must be fully within the red start area.

7.42 The match begins on the referee's whistle. The team may restart the run up to two times within the 5-minute limit. To restart, the robot must be returned to the start area and still meet all check-in requirements. Restarts require referee approval and the match clock does not stop during the process.

7.43 The competition rules in this rulebook apply; any unspecified issues are subject to the referees' final interpretation.

7.44 The competition environment may include imperfect conditions (e.g., lighting variations), which the robot should be able to handle. The use of camera flashes or other devices that could interfere with the robot is forbidden during the match.

7.45 The robot must have a start button. After the referee gives the start signal, the team should press the button to activate the robot. Remote starting is not allowed.

7.46 If the robot malfunctions or is damaged after the match has begun, the clock will continue to run.

7.47 If a team needs to reposition the robot back to the start area during the match (for example, to attempt a restart), they must get the referee's approval. Unauthorized touching of the robot or field will result in a 10-point deduction per instance, unless it is to prevent the robot from falling off the field.

7.48 Once the robot has completed the required sequence, the team must promptly inform the referee to stop the timer. If the referee delays stopping the clock due to uncertainty about task completion, the team cannot dispute the timing.

7.49 The time limit for the match is 5 minutes. If the task is not fully completed, the match time will be recorded as 5 minutes. Teams may end the run early, but the recorded time will still be 5 minutes.

7.5 Sub-Competitions- Autonomous Movement Challenge: Scoring

7.51 Each team has two attempts in this challenge, using a points system.

7.52 Each match has a maximum of 40 points (10 points for each of the four required stopping positions, including returning to start), for a total maximum of 80 points across both attempts.

7.53 Scoring for the robot's stopping positions is the same as in the Overall Contest's Table 2 (robot position scoring). For each designated area (C, D, E, and the return to A), points are awarded based on the portion of the robot that enters the area(As shown in Figure 8):

- Robot fully enters the area: 10 points.
- Robot more than half inside the area: 8 points.
- Robot partially (less than half) inside the area: 5 points.
- Robot does not enter the area: 0 points.

   Each colored area is scored only once. If the robot stops in the same colored area multiple times, only the highest score for that area is counted. If the robot's stop in an area is shorter than 3 seconds, that stop does not count for scoring.

7.6 Sub-Competitions- Autonomous Movement Challenge: Penalty Deductions

7.61 Robot crossing outside the black dashed line: -5 points each time (no penalty if exactly on the line).

7.62 Robot colliding with a wall: -5 points each time.

7.7 Sub-Competitions- Autonomous Movement Challenge: Ranking Calculation

   Teams are ranked by the total points from both attempts (maximum 80 points) in the **Autonomous Movement Challenge**. The team with the highest total score wins this challenge. If there is a tie in points, the team with the faster completion time ranks higher. If still tied, the team with the lighter robot ranks higher.

8.1 Sub-Competitions- Smart Object Handling Challenge: Field Specifications

8.11 As shown in Figure 11, the field for the Smart Object Handling Challenge is based on a portion of the Overall Competition field (including Area E of that field). It can be divided into three sections: the robot start area, the drop-off area, and the cargo collection area. (See official field diagrams for detailed dimensions in Figure 12.)

8.12 Start Area (Area a) – A gray area of 38 cm × 38 cm where the robot starts (the robot can be placed anywhere within this area at the start).

8.13 Drop-off Area (Area b) – A checkered area where cargo must be delivered. Its inner dimensions are 40 cm × 18 cm (with a 5 mm border). A cargo placement area (30 cm × 9 cm, same size as in the Overall Contest) will be randomly positioned within the drop-off area (Area b).

8.14 Cargo Collection Area (Area c) – The cargo collection area where blocks are initially placed. Its inner dimensions are 29.7 cm × 21.0 cm (A4 size, with a 5 mm border). The cargo collection area contains four positions for the blocks. The cargo collection area may be elevated to one of several heights (detailed later).

8.15 Cargo Blocks – Four wooden cubes (5 cm each side) labeled "F", "I", "R", "A". The labeled face

of each block is placed face-up and aligned as per the diagrams. The labels are printed on thick paper and affixed to the blocks using a low-reflectivity material.

8.16 The field's colors and materials are chosen to minimize any impact on the robot's sensors or performance, expecting the robot to adapt to minor variations in the environment. The actual field may have slight color differences or up to ±1 cm dimensional deviation.
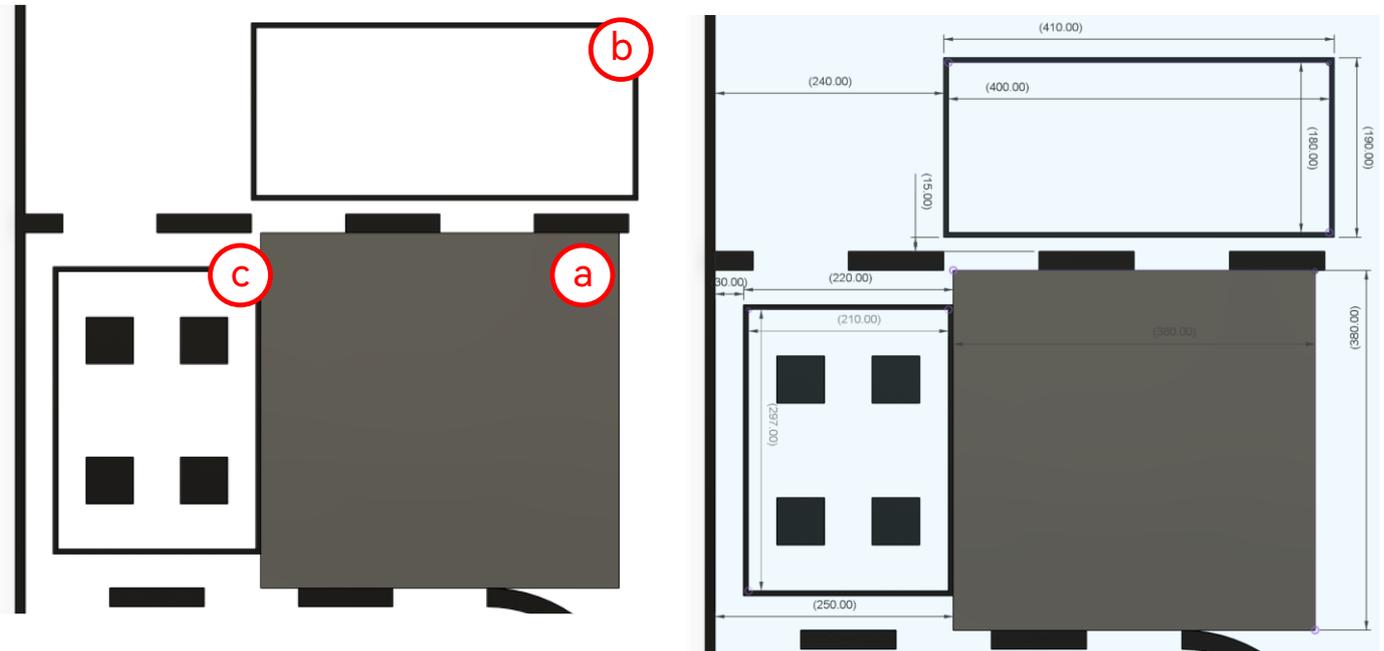

Figure 11. Illustration of the Smart Object Pick-and-Place Challenge (Left)

Figure 12. Dimension Diagram of the Smart Object Pick-and-Place Challenge Field (Unit: mm) (Right)

8.2 Sub-Competitions- Smart Object Handling Challenge: Competition Rules

In this challenge, the goal is to place four lettered blocks ('F', 'I', 'R', 'A') into designated target positions within the drop-off area. The initial positions of the blocks in the pick-up area, the height of the pick-up area (0 cm, 4 cm, or 8 cm), and the location of the cargo placement area in the drop-off zone are randomly set by the referees before each match. Within a 5-minute match, the robot must autonomously retrieve the blocks from the pick-up area (Area c) and place them onto the cargo placement area in the drop-off zone (Area b) at the positions corresponding to their letters. Successfully placing all blocks in their target positions within the time limit completes the task. Each team has two attempts for this challenge.

8.3 Sub-Competitions- Smart Object Handling Challenge: Field Inspection

8.31 The referees will randomly set each block's starting position in the pick-up area, the height of the cargo collection area (either 0 cm, 4 cm, or 8 cm, as shown in Figure 5), and the position of the cargo placement area within the drop-off area for each team's match. The cargo placement area will not be rotated and only repositioned within Area b(as shown in Figure 6). These settings are changed before each team's match.

8.32 After the referee sets up the blocks and field for the match, the team may inspect the block positions and other elements. Any objections must be raised immediately to the referee before the match starts. No objections may be made once the match has begun.

8.4 Sub-Competitions- Smart Object Handling Challenge: Match Start

8.41 Before the match begins, the team may place the robot anywhere within the gray start area (Area a).

8.42 The match begins on the referee's whistle. The team may restart the run up to two times within the 5-minute limit. For a restart, the robot must still meet all check-in requirements, and all blocks must be returned to their initial positions in the pick-up area. Restarts require referee approval, and the timer will continue running during the reset.

8.43 These official rules govern the contest; any details not specified will be resolved by the referees, who have final authority.

8.44 The contest environment may include variable conditions (lighting, etc.) that the robot must overcome. No external devices (e.g., camera flashes) that could interfere with the robot are allowed during the match.

8.45 The robot must have a start button. After the referee gives the start signal, the team should press the button to activate the robot. Remote starting is not allowed.

8.46 If the robot experiences any malfunction or damage during the match, the clock continues to run.

8.47 If the team needs to reposition the robot (or reset blocks) during the match (such as for a restart), they must have the referee's approval. If team members touch the robot or field without permission, a 10-point deduction may be applied, unless intervening to prevent the robot from falling off the field.

8.48 After completing the task, the team must notify the referee to stop the timer. If the referee does not immediately stop the timer because they cannot confirm task completion, the team cannot dispute the additional time.

8.49 The time limit for the match is 5 minutes. If not all tasks are completed, the match will be recorded as 5 minutes. Ending the match early will still result in a recorded time of 5 minutes.

8.5 Sub-Competitions- Smart Object Handling Challenge: Scoring

8.51 Each team has two attempts in this challenge, with scoring based on points.

8.52 Each match has a maximum of 40 points, all derived from block placement (there is no separate robot position score in this challenge). The highest total score across two attempts is 80 points.

8.53 Block Placement Scoring: The scoring criteria for block placement are the same as in the Overall Contest (see Table 1 above). For each block:

- Completely in the target position: 10 points.
- Over half in the target position: 8 points.
- Partially on the target (less than half in): 5 points.
- Delivered into the drop-off area (Area b) but not on the target: 2 points.
- Touching the drop-off area boundary line, or block is toppled (letter face not upright): 0 points.

8.6 Sub-Competitions- Smart Object Handling Challenge: Ranking Calculation

Teams are ranked by the total points from both attempts (maximum 80 points) in the **Smart Object Handling Challenge**. The team with the highest total points is the winner of this challenge. If teams are tied in score, the faster completion time is used to break the tie; if still tied, the lighter robot wins the higher rank.

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9. Violations and Penalties

9.1 The following actions are considered violations:

- ➢ The robot moves before the start signal (whistle).
- ➢ During the match, a team member touches or interferes with the robot without permission.
- ➢ The robot intentionally collides with an opponent or interferes with another team's run.

9.2 Depending on the severity of the violation, referees will impose the following penalties:

- ➢ Minor Violation: The score for that match will be recorded as 0 points.
- ➢ Serious Violation: The team will be disqualified from the competition.

Teams must comply with the referees' decisions. Any objections must be raised immediately to the organizers. The organizers' committee holds the final decision authority.

10. Addition

10. Additional Awards

In addition to the Overall Contest trophies (Champion and Runner-up) and the winners of the two sub-contests, the competition will present a Technical Design Innovation Award to one team. This award encourages innovative thinking and technological application in the robot's design, including overall design architecture, the technologies and materials used, and innovative methods of functionality implementation. The evaluation for this award will be based on the robot's innovative features and the effectiveness of the applied technologies.

11. Other Matters

Participating teams must adhere to the regulations outlined in the rulebook and official announcements, including schedules and competition rules. For unforeseen circumstances not specified in the regulations, teams must comply with the referee's decisions. Any objections should be raised immediately with the organizing committee, which holds the final decision-making authority.