RULES OF OPEN Category – 2023

Version 1.0 – April 2023

***Advanced* Supporting Robots for Warehouse Operations**

Introduction

The competition context is aimed at automating an environment with a large number of packages to be organized, Figure 1. The essence of the competition is extracted from environments such as warehouse, product distribution center, store stock, etc.

Warehouses automation is already a reality in large companies like Amazon and Alibaba, but it should be a reality in midsize companies soon. Think of a possible solution. Participants must build an agile and fast robot to organize as many packages as possible in a limited time.

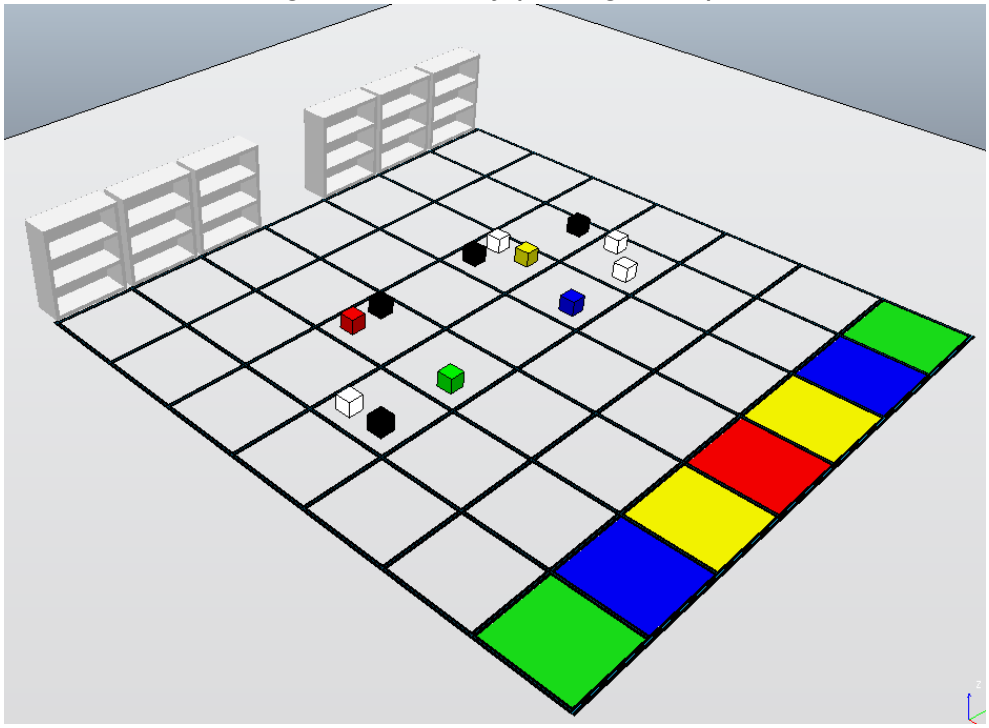

Figure 1 – General view of the arena

The goal

The robot can move freely in the scenario but cannot collide or push a package out of the package's area. To reach the challenges of the competition, the robot must take each package and leave it to its destination. The robot will not know his initial position in the scenario either the position of the packs in the package's area. The objective is to take packages from a specific location and take them to predefined locations, so that, at the end, the packages are in a desired arrangement in the proposed scenario. The specific objectives are:

1. Take colored packages (yellow, red, green, blue) and move them to the unloading regions with equivalent colors.
2. Pick up packages containing 2D codes and move them to any respective position on the shelves.
3. Pick up packages with alphabetical values and take them to any respective position on the shelves.

Packages

Packages can be marked by color, 2D codes or alphabetical values. The possible colors for the packages are green, yellow, blue and red. The 2D code is a bi-dimensional representation containing 9 combinations, from one to 9, according to the markers that can be obtained from the site https://chev.me/arucogen. The alphabetical packages are white and the 2D code packages are black. There is a specific region in the scenario where the packages are initially positioned, called the loading region.

Package Specifications

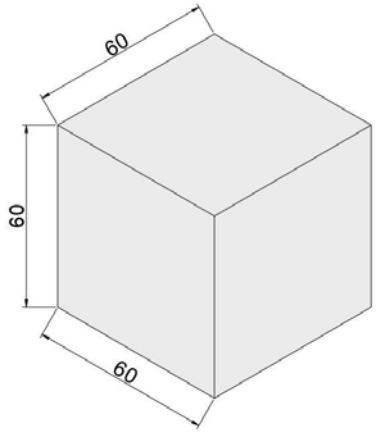

Figure 2 – Shape and dimensions of packages.

The packages are cubes measuring, approximately, 60mm x 60mm x 60mm, Figure 2, made by a 3D printer from the most common filaments on the market, ABS, PLA or PETG. The approximate settings for printing are 1 mm of thickness, 10% infill density, 1 mm thickness at the bottom and top. The approximate weight is 50 grams, which can vary 10 grams.

The alphabetic cubes are white and have the same letter on the 4 side faces. Values are one capital letters, from A (1st letter) to I (9th letter), boldface, using font Arial and font size 140 (equivalent to a letter with the height of 49 mm). The letters that can appear in the cube's faces are A, B, C, D, E, F, G, H, and I.

The 2D code consists in markers that allow for the unique identification of each cube, centered on the side faces of the cube with a white edge of 5mm od thickness. Each 2D code should occupy the complete face, being printed in each of the four side faces In Figure 3 you can see all the possible 2D codes.

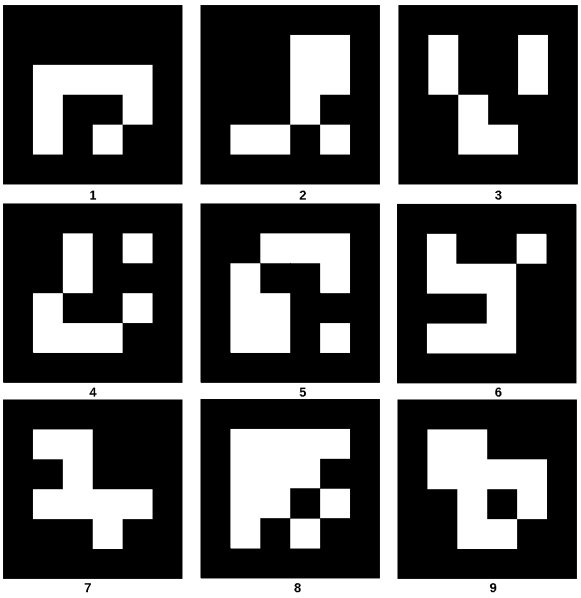

Figure 3 – 2Dcodes from 1 (top left) to 9 (bottom right).

Scenario

Each package has a tag that identifies it and, consequently, its destination or destination region. The scenario contains three types of regions: transit region, package loading region and package unloading region.

The scenario is formed by 49 (7x7) squares, see Table I, for free circulation of the robot, for loading and unloading packages. The package loading region consists in two areas centralized in the scenario. Each area consists of four squares. Table I shows the two loading areas marked in gray and indicated by the squares {(3,2), (3,3), (4,2), (4,3)} and {(3,5), (3,6), (4,5), (4,6)}. This numerical and gray marking will not be present in the real scenario and serves as a guide to better explain some details of the scenario. The white background squares, as shown in Table I, are aimed to allow the free circulation of the robot. There are two unloading regions: one for alphabetical or 2D coded packages and one for colored packages.

Table I: Arrangement of squares.

1,1	1,2	1,3	1,4	1,5	1,6	1,7
2,1	2,2	2,3	2,4	2,5	2,6	2,7
3,1	3,2	3,3	3,4	3,5	3,6	3,7
4,1	4,2	4,3	4,4	4,5	4,6	4,7
5,1	5,2	5,3	5,4	5,5	5,6	5,7
6,1	6,2	6,3	6,4	6,5	6,6	6,7
7,1	7,2	7,3	7,4	7,5	7,6	7,7

Arena Settings

Each square in the scenario is determined by a black border, with an internal size of 30 cm x 30 cm and with an internal white color. The width of the border line is approximately 1.9 cm. The size of the scenario is approximately 225.2 cm x 225.2 cm. At the bottom, the 7 squares are colored and represent the region for unloading the colored packages (Figure 4).

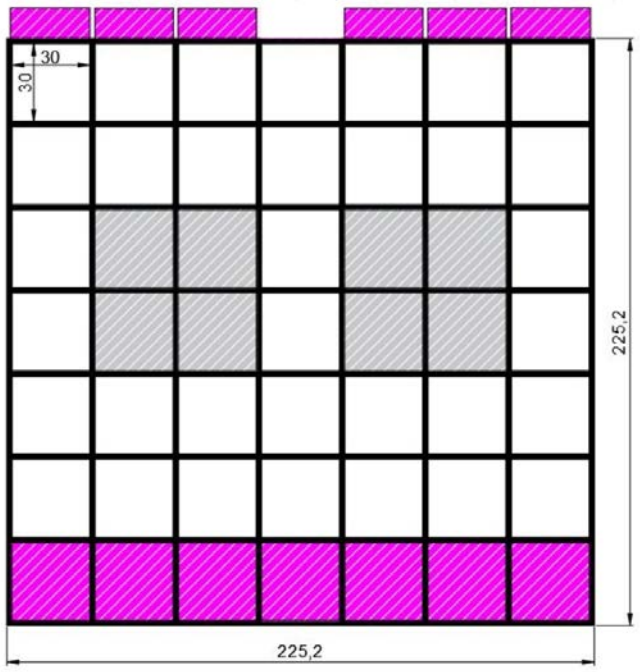

Figure 4 - Dimensions of the competition arena with loading and unloading regions hatched in gray and purple, respectively.

In Figures 5 and 6, perspective views of both alphabetical and 2D coded packages without the white edge are presented for illustration, in both front and rear views.

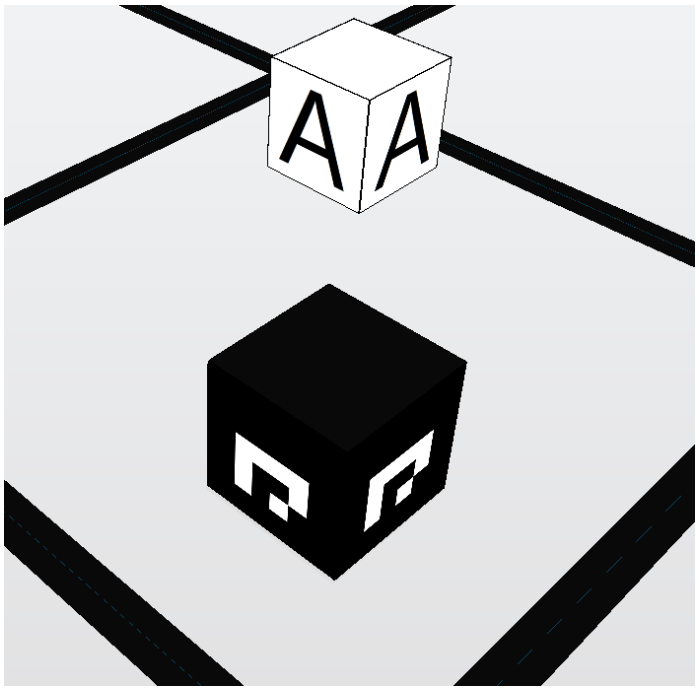

Figure 5 – Perspective view from blocks with 2D code and Alphabetical identification. Front View.

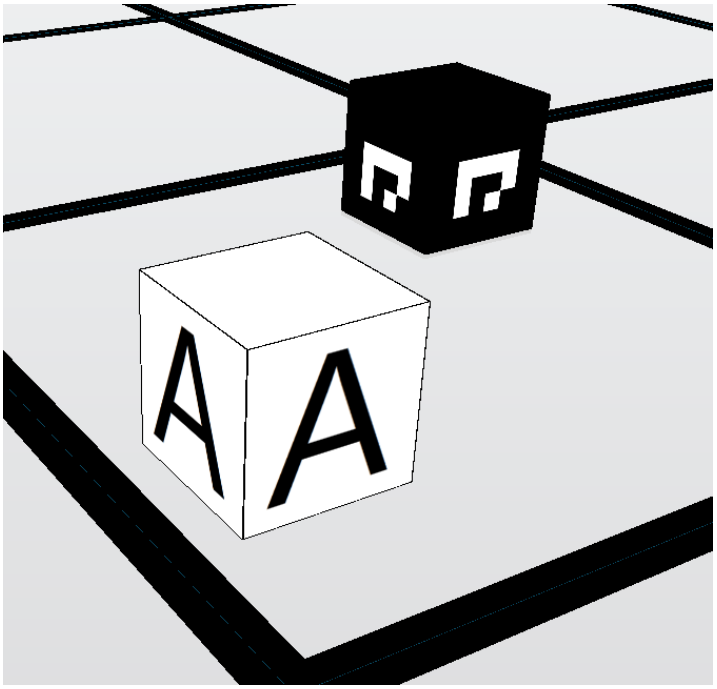

Figure 6 – Perspective view from blocks with 2D code and Alphabetical identification. Rear View.

The upper region, adjacent to the external boundary of the arena, has 2 sets of 3 aligned shelves, one set between the first and the third square, and other set between the fifth and seventh square. The shelves are arranged next to each other and together they have 9 compartments for each set. The compartments are identified between 1(A) and 9(I). The compartment in the lower left corner has a value of 1(A), the second in the lower left corner has a value of 2(B), the highest compartment on the right has a value of 9(I), (Figure 7).

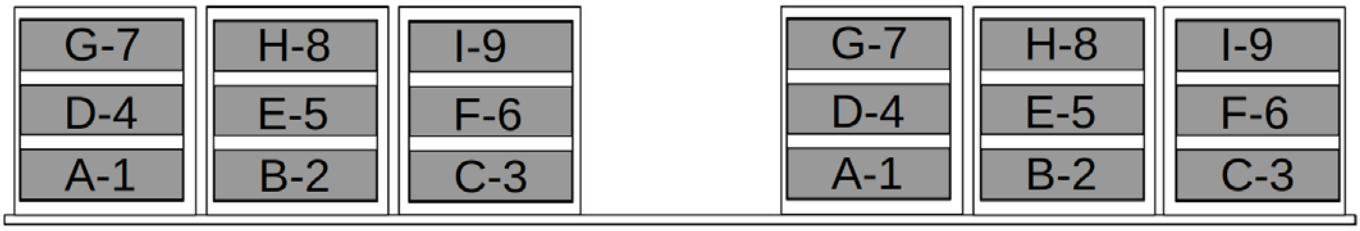

Figure 7 - Front view of the shelf compartments numbered A (1) to I (9).

Each shelf measures approximately 30 cm wide, with 3 parts, 10 cm high and 10 cm depth. Thus, since the shelves are made of 1.5 cm thick MDF, their total dimensions will be approximately 36 cm high, 30 cm wide and 11.5 cm depth (Figure 8). Since there are cubes with both alphabetical and 2D codes, only one cube can be inserted in any position of the shelves. But the team can choose in which shelf it will store each cube. So, the team can put the cube “A” in the left shelf, position “A/1”, and then the cube “1” (2D code) in the right shelf, position “A/1”, or vice versa. And there is no need to put only alphabetical cubes in one shelf, and cubes with 2D codes in the other shelf. There will be no penalty for “mixing” the cubes in both shelves, so each team can optimize its approach to put the cubes in the shelf that is more adequate according to the team’s strategy.

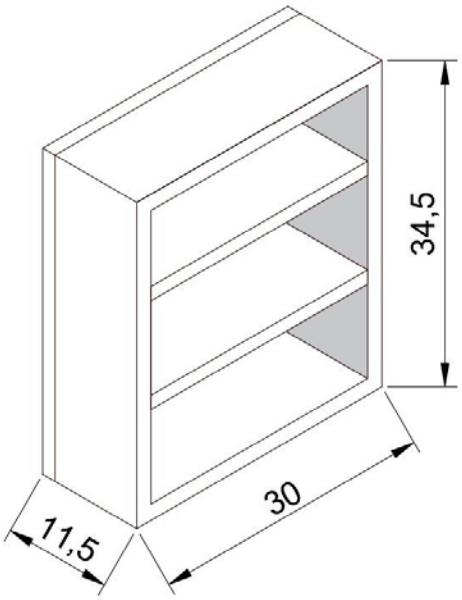

Figure 8 - Dimensions of unloading shelves.

Lighting Conditions

The local committee will try to provide uniform lighting throughout the arena. However, teams should be prepared to calibrate their robots based on the lighting conditions of the venue. The local committee will take actions to minimize the effects of shadows and natural light, however these factors cannot be completely eliminated. Therefore, it is highly recommended that competitors design their robots to be immune to the variations of lighting that can be presented in the venue during the competition. From the start of competitions, the teams will "play" under existing lighting conditions without discussion or claims.

The Competition Rules

For each team in each round, the positions of the packages will be defined by draw. There will be 12 packages randomly positioned in the scenario at the beginning of each round: 4 colored, 4 alphabetical and 4 2d coded. After the draw, the team will not be able to modify their robot in any way. Changes and re-scheduling are allowed only after the round has ended.

STARTING POSITION

At the beginning of the round, an initial position and robot orientation will be drawn (the same for all teams) and the packages will be positioned by the organization in the arena. The organizers will provide a way to randomly define which blocks will be positioned were in the loading area.

The random choice of the initial position/orientation of the robot will be made using the website <https://www.random.org/integers/> with two distinct configurations:

- For arena position: 10 numbers between 1 and 7 will be drawn and presented in two columns in the order they are drawn. The robot's starting position in the arena will be the first set of numbers that indicate a white area in Table 1;
- For the robot's orientation: a number between 1 and 4 will be drawn. It alone will represent the robot's orientation in the arena. The possibilities are made using the shelves as a reference and are:
    - 1 - facing the shelves;
    - 2 - with the shelves to the left (rotated 90º clockwise- to the right- of the shelves);
    - 3 - with the shelves at the rear (rotated 180º to the right in relation to the shelves);
    - 4 - with the shelves to the right (rotated 270º to the right in relation to the shelves).

When the robot starts its round no intervention can occur, otherwise it will be considered as a restart. The robot starts the race at the starting point and will be transferred to this position on each restart. Each robot will have a maximum of three attempts per round, therefore, 2 authorized restarts. For each restart, all moved packages are placed back in the initial position of the first attempt, but without stopping time. The organizing team will be responsible for re-arrange the packages.

If the robot presents an obvious mechanical problem, if the judge allows, the participating team can make an intervention at the robot. They can start again (it does not count as a restart) and the time does not stop. As a clear example of a mechanical problem, we can cite the detachment of a wheel, motor, sensor, battery without power, or any difficulty not associated with a bad design that prevents its normal operation and can be repaired within the framework of the form fast. The team, in this case, and only after authorization of the judge, can go to his bench and fix the robot. If the judge does not understand that there was a mechanical problem, it will not authorize the maintenance of the robot. Time does not stop at all.

A round is declared finished in three ways:

- If the round´s time is finished (7.5 minutes).
- If the team decides to terminate its participation, even if all goals have not been met. It is worth the score obtained and the time spent until the moment of closure.
- The robot has already used the 2 authorized restarts.
- When all packages are positioned in an appropriate location.
- If the robot leaves the arena four times.

The robot cannot leave the arena. Each time you leave the area, you will be punished with **-100 points** and the **fourth time** that this occurs the round will be finished. Exiting the arena means when any part of the robot encounters the floor out of the arena. If the robot gets stuck or loses its balance, team members can make an intervention in their robot, but it will be considered a restart, and time measurement will not stop.

Scoring

The score has two (2) parts. The first part is related to the TDP (Team Description Paper) presentation, and the second part is about the performance in the arena (70% of total score).

The **TDP presentation (30% of total score)** must reflect the document submitted to the organization for team registration. The presentation will be performed in a meeting with at least one representative of each team. The time to each team presentation cannot be less than 5 minutes nor more than 10 minutes. The structure of the meeting will have the following order:

1. Entry of all evaluators, members of the team that will be under evaluation and other spectators - without a defined time;
2. Screen sharing start - 1 minute;
3. TDP Presentation (not less than 5, and no more than 10 minutes);
4. Questions from evaluators - up to 5 minutes for each evaluator;
5. Audience Questions - up to 5 minutes;
6. End of sharing - 1 minute.

The total time for each presentation must be a maximum of 30 minutes including all the steps described above.

There are 5 (five) evaluation criteria, each contributing to 20% of each evaluator's grade. The score will be the average of the final grades of each evaluator. The criteria will be:

- Adequacy of presentation time: considers whether the teams made effective use of the time available;
- Mastery of the theme: considers whether the members who participate in the presentation master the theme of the challenge and the team project;
- Strategy: considers whether the team presented a clear and consistent strategy for solving the problem;
- Innovation: considers whether the team's project brings any innovation both to the solution of the problem and to the project itself;
- Alignment with the real problem: considers if the proposed approach would be applicable in the real world (for example in a real warehouse).

To guarantee the greatest possible equality in the evaluations, the judges must not have any relationship with the teams that will be evaluated. If this type of conflict of interest occurs, the judge in question will not be able to evaluate the team in the TDP presentation.

The **performance in the arena (70% of total score)** is counted in two phases. The first phase indicates the attempt to take the first package to the correct position. In the second phase, the score is assigned to each attempt to pick up and take the package to a destination position.

In the first phase, the scores are given as follows:

- 10 points for positioning yourself in front of a package;
- 20 points for picking up the package;
- 50 points per walk in the correct direction of the destination area of the package;

After reaching the 80 points of this first moment, no more points will be counted for this phase.

In the second phase, the robot will be able to take any package to its respective position. **The first package of each type delivered will give the double of its points**. The scores for phase two will only be valid if the robot completely solves each task, picking and delivering each package to a corresponding position in one of the shelves, or to the correct colored region. The following scores are possible:

- Colored Packages:
- 100* points for each color package delivered to the correct region;
  - Maximum 500 points for 4 correct attempts (the first package correctly delivered will provide 200 points, the other 3, 100 points each).
- 2D code Packages: 125* points for each 2D code package delivered to the right position;
  - Maximum 625 points for 4 correct attempts (the first package correctly delivered will provide 250 points, the other 3, 125 points each).
- Packages with alphabetical values: 150* points for each alphabetical package delivered;
  - Maximum 750 points for 4 correct attempts (the first package correctly delivered will provide 300 points, the other 3, 150 points each).

(*The first package of each type will give the double of its points.)

If any team reaches the maximum score of the match, an extra challenge will be launched. The robot enters the arena in a random position to pick up a package from one of the shelves in a random position. The robot must deliver the package to one of the loading regions. The score for the extra challenge is 4000 points. The competition judge is completely free to define the details of the extra challenge.

If the robot touches the package, it can only be removed from the loading area if the package is lifted. In this context, if the robot drags the package out of its area, the team will be penalized with a negative score relative to the score value associated with the package.

General rules:

- For each restart, the score is reset, the time is kept, and the packages return to the starting position. Each round has a maximum of two restarts. It is up to the team to decide whether to keep the score so far and to end the participation or if they will try a restart, with a new score returned to zero. It will ALWAYS BE CONSIDERED as the team's score for the round, the score of the last try.
- The first and main criterion for determining the winner is the highest score. If there is a tie the second criterion will be the shortest time. In the case of a tie in both criteria, an extra round for tie-break will be held. During the final rounds, when there is a tie in the score, there will be an extra round immediately to determine the 1st, 2nd, and 3rd places.

Any consideration or exception is at the discretion of judges and organizers.

The execution of the rounds

Before starting the rounds, if the team finds it is necessary to do a color or lighting calibration, an extra minute will be given to each team before its round. There are two types of rounds, qualifying and final:

Qualifying rounds:

- All registered teams in the IEEE Open category must participate.
- Consists of 04 rounds per team. This number may vary, at the discretion of the judges / organization of the event.
- The maximum time per team to perform the round is 7.5 minutes with 1 extra minute of initial calibration.
- Each team can restart their robot twice per round. For each restart, the score will be zero and the time will not stop (time running).
- The best score of the four rounds will be considered to decide which teams will advance to the final rounds. The four best teams will be qualified to finals.
- If there is a tie, it will be chosen who got the score in the shortest time. If the tie persists, a new round between the tied teams should occur.
- Each team has 1 minute to appear in the arena, after that period, the time of the competition begins to run.

Final Round:

- The top four teams in the qualifying rounds are in attendance.
- It consists of 03 rounds.
- Maximum time per team to perform the test is 7.5 minutes + 1 minute of calibration.
- Each team can restart their robot twice per round. For each restart, the score will be zero and the time will not stop (time running).
- The best score of the 03 rounds will be considered to determine the champions.
- If a tie occurs, a fourth round will be played between teams tied to define their place.
- Each team has 1 minute to appear in the arena, after that period, the time of the competition begins to run.

Requirements to Participate

Those interested in participating in the Latin American Robotics Competition LARC IEEE OPEN category must form teams of undergraduate or graduate students in any educational institution in any country. Nevertheless, high school students will also be allowed to participate. To register, teams must submit a document describing the development and operation of the robot (TDP) in IEEE format. This TDP will be used for the winners to make a brief report to the other competitors. Please, verify the deadlines on the event website.

The Jury

The JURY is composed by a member of organizing chairs, an auxiliary of the organization and a member of another team that is not competing in the match, chosen before the match starts. The JURY is responsible for the execution of the round.

Extraordinary Situations During the Competition

If there is any situation not covered under the above-mentioned rules, or any doubt about the score, it will be up to the judges and the organizers of the competition to consider the case in the greatest possible impartiality and decide. It is important to mention that any fact that it is not explicit in the rules cannot be automatically considered as allowable in the competition. Missing facts will always be treated as **extraordinary situation,** and it must be judged as allowable or not by the judges and organization.