REGULATIONS
OF THE RTC CUP COMPETITION
NATIONAL & INTERNATIONAL STAGE

1. General Provisions

1.1. At the RTC Cup national and international competitions the participants are presented with a testing area. The testing area consists of sites of varying complexity from rugged terrain to the consequences of disasters (such as earthquake, tsunami, rockslides, mud descents and the like).

The purpose of competition at such a test site is to inspire and encourage young roboteers to create robots capable of working in extreme situations, either completely replacing a human being or acting as an assistant.

1.2. In the international stage RTC Cup competition the robot must pass as many sections of the testing area as possible within the given time, performing the set tasks.

2. Testing area

2.1. The testing area is an automated, reconfigurable obstacle course consisting of cells that a mobile robot must be designed to get through. The general view of the possible configuration of the testing area is shown in Figure 1.

2.2. The testing area cell is a section bounded on the perimeter with a black profile.

2.3. A detailed description of the structure (types of obstacles and tests it contains, and their specifications) can be found in **Annex No. 1 "Description of the testing area"** of the current document.

2.4. The configuration of the testing area changes every competition and is not communicated to the participants in advance.

2.5. The list of obstacles and the points awarded for them are announced at least one week before the competition. Any sections may be added just before the competition.

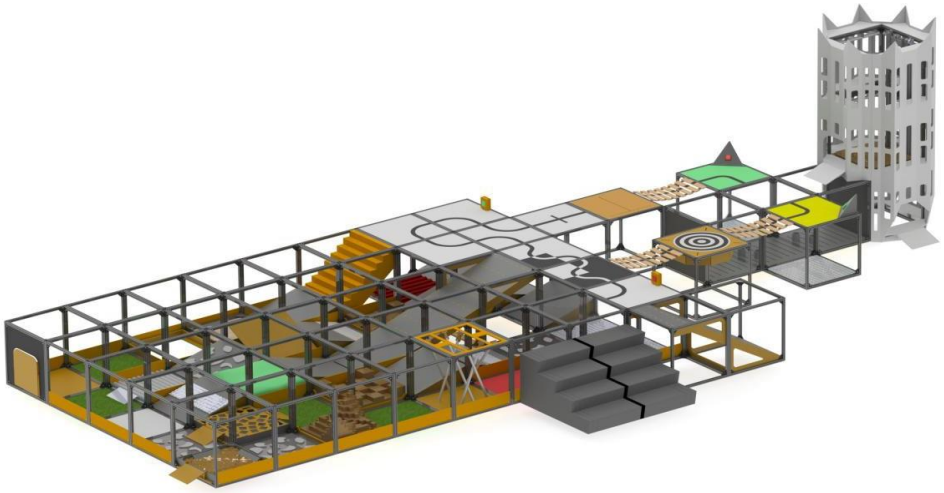


Figure 1 General view of the testing area configuration

3. Categories

3.1.1. Competitions are divided into two categories: **"Scout"** (age limit – from 7 to 14 years inclusive) and **"Extreme"** (age limit - from 7 years and older).

3.2. In the **"Scout"** category, the robot is in the field of view of the operator, who can directly observe the robot's actions with his own eyes. The robot is controlled remotely. During one attempt, two robots (or one by the decision of the panel of judges) pass the testing area at the same time. Pairing of teams is done during drawing procedure held before the first and second attempts.

3.3. In the **"Extreme"** category the robot is out of sight of the operator (participant), and controlled remotely, using the robot's video vision, and measuring equipment mounted on it.

One robot passes the testing area during one attempt.

4. Requirements for a team

4.1. At the international and national stage, no more than two people are allowed to participate in the team (not counting the leader), in other cases - up to four. The robot can only have one operator. The quota for the number of teams is determined 1 month before the competition and is announced a month before the stage in information messages to participants, on the competition pages in social networks and on the website.

4.2. It is allowed to change the operator between attempts.

4.3. The team can participate with only one robot in only one category in the course of current competition.

4.4. It is forbidden to break and contaminate the testing area.

5. Requirements for a robot

5.1. Robots on any elementary base that do not pose a threat to others or to the testing area may participate in the competition.

5.2. Recommended overall dimensions of the robot (according to the dimensions of obstacles in the testing area) - no more than (H x L x W) 350x400x400 mm in the starting position. After the start of the attempt, the robot can change dimensions indefinitely.

5.3. The weight of the robot should not exceed 10 kg.

5.4. The robot should have an on-board power source.

5.5. The robot is controlled wirelessly. The minimum distance between an operator and a robot is approximately 10m. In this regard, robots controlled by IR remote controls are not allowed to compete.

Figure 2 Examples of common IR remote controls

5.6. Participants are allowed to deploy a wi-fi network to control the robot during the attempt.

6. Procedure and criteria for selection at the competition

6.1. Before the competition attempts begin, robot training group races are held, during which participants can explore the testing area and check what tasks their robot can pass.

6.2. **Qualification:** performance of the basic passing task, which is mandatory to pass - crossing the maze threshold (43 mm) and entering the first cell.
The performance of this task is evaluated by the judges during training (pass/fail).

6.3. If the robot is unable to perform a basic task, the team is disqualified from the current attempt and waits for a break between attempts to try to qualify before the next attempt. If in this case the qualification is not passed, the team is disqualified from the competition.

6.4. **Mandatory conditions for passing an attempt**

6.4.1. For the results of an attempt to be considered, the following items shall be available and used:

- **"Scout" and "Extreme" (up to 16 years inclusive):** functional **sensors or manipulator** (successful completion of a task with the use of elements of self-containment or manipulator);
- **"Extreme" (from 17 years and older):** functional **sensors** (successful completion of a task with the use of elements of self-containment);

6.5. **Constructive prohibitions:**

6.5.1. It is prohibited to use liquid, powder, and gas substances, including as a weapon against a rival robot (for the "Scout" category).

6.5.2. Do not use flammable substances.

6.5.3. No interference in electronic equipment with frequencies greater than 100 kHz and radiated power greater than 10 mW is permitted, except for standard radio and video communications.

6.5.4. Robots that violate the above prohibitions will be disqualified from the competition.

7. Competition process

7.1. The robot must pass the testing area under the control of the operator by completing tests and performing tasks. There are beacons of different colors in the sections of the testing area, the robot should collect and place them in the appropriate color zones. Autonomous areas are traversed with the use of sensors mounted on the robot.

7.2. The robot does not have to go through each cell of the testing area. The operator can decide how to build his own route.

7.3. The competition consists of 2 attempts for each category.

7.4. One attempt takes 10 minutes.

7.5. Score of the best of two competitive attempts will be counted.

7.6. 30 minutes before the start of the attempt, the team enters the preparation zone. 10 minutes before the attempt, the operator with the robot must be in the competition area, ready to start, and notify the judges at the registration desk of his readiness.

7.7. The attempt can be **postponed** in case the participant is not ready **at least one attempt before** the attempt of the participant. Otherwise, **the postponement will be denied**.

7.8. Postponement of an attempt will result in a **penalty** for the future result of the attempt (see Annex 2 "Points" to the current document).

7.9. An attempt may be postponed only **once**.

7.10. The team should independently monitor the schedule of attempts (the order of attempts may change depending on the appearance of postponements and disqualifications).

7.11. **Preparation for an attempt:**

A participant in the category "Scout" has 3 minutes, in the category "Extreme" - 7 minutes to prepare for the start from the moment the participant is called to the starting area (if necessary). In the "Scout" category, both participants go to the start simultaneously. After 3 minutes, the timer starts automatically for 10 minutes - time of

attempt. You cannot postpone an attempt if you are not ready. The participant may start at any time from the start of the current attempt as soon as the necessary repairment is done. In case of a single participant in the testing area, if after the time allowed for preparation the robot cannot start, the team is disqualified from the attempt.

7.12. **Start** is located in front of the Maze entrance. In case there are two entrances, it is determined in advance where the team should start when scheduling. On the second attempt, the entrance changes to the opposite.

The robot is required to start its movement from the "start" cell indicated by the judge and move through the Maze to any other exit. You cannot go out through the fields marked as "start" and go around the maze. If the robot left the maze through the exit, it could move in and out of any cell in the future.

7.13. Once a team has passed its autonomous route (corresponding to the start), it has the right to pass another if it is not currently occupied by the other participant.

7.14. No points will be awarded for re-passing the cell.

7.15. If the robot performs autonomous actions, the participant **must** notify the judges about this at the beginning of the attempt and directly before the start of these actions. Otherwise, passing of the test will not be counted.

7.16. In the "**Scout**" category only the robot operator is allowed to be present in the testing area, the rest of the team members and the leader are behind the fence when an attempt is made.

7.17. When passing an attempt in the "**Extreme**" category, only the operator is in the booth; the other team members and the leader take places specified by the judge. If you try to talk to the operator without the permission of the judge, the team is disqualified.

7.18. Interference in control (repair) can be carried out by both the operator and any team member. After the intervention, all participants (except the "Scout" robot operator) must leave the testing area.

7.19. Holding a rival robot in place for more than 20 seconds in any way is considered to stuck up, and both robots are moved back by the judge to the cells they had passed before, without penalties.

8. Scoring criteria

8.1. The "Scout" and "Extreme" categories are evaluated according to a single point system, but are awarded separately, as the division into categories implies different levels of complexity.

8.2. The scoring criteria for a team's performance is the number of points gained during the attempt. The best attempt from the past is counted.

8.3. Points are accrued for passing through the cells of the testing area and completing tasks. The number of points depends on the complexity level of the task.

8.4. A cell is passed if the robot entered it with the whole base and left the other end

(exception - dead-end cells).

8.5. **No points** will be awarded for re-passing the cell.

8.6. A cell may or may not contain a test.

8.7. If two teams have the same number of points for the best attempt, the team that completed the attempt in less time wins. In case time is the same, the team with the highest total score of two attempts wins.

8.8. The scoring system, the table of points and conditions of passing the sections of the testing area are given in **Annex 2 "Points"** to the current document.

9. Tasks Description

9.1. **Tasks in the Manipulator category**To qualify for the manipulator category, the robot must perform the following tasks with any additional device capable of moving independently of the main chassis: manipulator, levers, etc.

9.1.2. If the robot performs one of the following tasks using a basic, load-bearing chassis structure (e.g. runs a button with a wheel or turn a pipe with a wheel), points will be awarded for performance, but the robot will not be qualified in the manipulator category.

9.1.3. **Opening the door** – pulling the door with the handle.

9.1.4. **Buttons** - there are three types of buttons in the testing area: the buttons in the "Capture the flag" task, the button that turns on the light in the "Fog" cell, the buttons inside the Tower on the elevator platform.

Task: press the button and turn on the light / activate the elevator.

9.2. **Pipes** – The "Pipes" task is presented in the testing area in two versions: straight (parallel) pipes and omni (omni-directional) pipes.

Tasks: remove a pipe (pull it out of socket) and/or turn a pipe (half a turn / full turn).

9.3. **Valves** – a panel with a set of various valves in the "open" position is mounted on the wall. The valves can be lever-operated and swiveling.

Task: Turn the valve to the "closed" position.

9.4. **Debris** - silver-gray items of various sizes, shapes and weights scattered over the testing area.

Task: capture and delivery of items to the gray container.

9.5. **Ball in the trench** – standard tennis balls located in one of the two grooves of the "Trench" test.

Task: capture and delivery of ball to the second groove.

9.6. **Overturn of the robot** (see section "Overturn" Task").

9.7. **Beacons –** conventional aluminum soda cans wrapped in tape.

Task: capture and delivery of beacons to the designated area or special field (colorful cell in a small cube).

9.7.1. General rules of beacon collection

- To be awarded points for beacon capture - the capture and lifting of the beacon must

be carried out at a height of at least 20 mm, for not less than 1 second. However, this is not a requirement for being awarded delivery points, the beacon can be pushed or rolled into the designated area.

- One beacon can be captured by the robot only once.
- A beacon is considered to have entered the zone if it touches the zone field with any part.
- If the beacon has touched a field of the corresponding color zone and left this zone, the hit is still counted.
- No re-delivery of an already delivered beacon is possible.
- The location and number of beacons shall be determined by the judges before the competition.

9.7.2. **Special beacons**

9.7.2.1. **Mini-tower** – a pedestal, which is a miniature copy of the tower on which a standard beacon is located.

Tasks: capture the beacon with the robot manipulator.

It is allowed to drop the beacon from the tower and further capture and/or delivery, but in this case, points are awarded for the capture of the beacon as for an ordinary beacon.

9.7.2.2**. Special beacon** – a colorful beacon located in the maze. Delivery - depending on the situation, either to the basket or in the hatch.

9.7.2.3. **Beacon with a marker** – a black and orange beacon that has a marker inserted. There are targets glued to the wall in the same maze cell at different heights.

Task: Touch the target marker and leave a visible trace. The closer you get to the center of the hit, the more points the team is awarded.

9.7.2.4. **Autonomous (white) beacon** – a beacon, which is at the intersection of the autonomous route. Stand-alone capture of such a beacon is performed using a rangefinder, while traveling along the route. Stand-alone delivery can be made to the field with a line from one intersection to another.

The completion of the task is also counted in the Autonomy category.

9.8. All other actions with the manipulator are agreed with the panel of judges privately before the attempt.

10. Tasks in the Autonomy category

10.1. The "RTC Cup" competition includes autonomous areas in the testing area.

10.2. Before the start, the judges must be notified of the actions that the robot will perform automatically. Also, during the attempt, the participant should announce the beginning and end of the autonomous mode of the robot loudly.

10.3. The autonomous mode will only be counted after confirmation by the judges.

10.4. An autonomous action is defined as the passage of a section without operator control, necessarily by using any sensors.

10.5. Movement on encoders or timer (just "motors forward") is not considered autonomous

mode.

10.6. The program and sensors may differ from the recommended ones listed below as an example.

10.7. Switching the autonomy on/off must take place remotely, and the participant must not touch the robot. In this case, the number of automatic mode switches is not limited.

10.8. During an attempt, one test can be completed either autonomously or manually, but points will then be counted **only** for passing autonomously.

10.9. **Traveling along the line** – is performed by means of a light sensor or vision system on lines (white fields, inclined lines of the maze) and bridges.

10.10. **Autonomous (white) beacon** – a beacon, which is at the intersection of the autonomous route. Stand-alone capture of such a beacon is performed using a rangefinder, while traveling along the route. Stand-alone delivery can be made to the field with a line from one intersection to another.

The completion of the task is also counted in the Manipulator category.

10.11. **Traveling inside the maze along the walls** - only on 3-cube sections that make a corner turn. The autonomy is counted if the moving along the walls of the corner cube is carried out without interruption. Methods of execution: moving along the wall using a rangefinder or a compass, gyroscope, or accelerometer, as well as vision systems.

10.12. **Autonomous capture of items and beacons** is carried out using a distance sensor or vision systems. In doing so, the robot must be turned away from the item being captured and be at least 10 cm away from it.

10.13. **Moving along a complex trajectory** (up/down stairs, passage of "ravines", "rails", "hypnosis disk", "oblique ramp-2", "logs", "fog", "hoof") along a line, using a compass, gyroscope or accelerometer, vision systems, combined methods that include the use of other sensors (e.g. a distance sensor).

10.14. **Reading a QR code by the robot** and displaying the decryption code on the screen (for "Extreme").

10.15. **Reading hazard sings by the robot** and displaying the recognized text on the screen, with the sign itself highlighted on the screen (for example, with a frame). "Extreme" tasks

10.16. **Autonomous overturn of the robot** (see section "Overturn" Task").

10.17. When performing autonomous tasks, the rule "hands off the remote control" applies - the participant must not touch the robot remote control. A touch is allowed to activate/deactivate autonomous mode.

10.18. All other actions with the sensors are agreed with the panel of judges privately before the attempt.

11. "Overturn" Task

11.1. The overturned robot on its side or turnedupside down comes to its initial state (stands on the "wheels").

11.2. After the overturn, the robot is able to continue moving without a repair.

11.3. The overturn is not counted if done from the vertical stand, i.e. when the robot rests on its front or rear.

11.4. Overturn points are awarded only once per attempt.

11.5. **Controlled overturn**

11.5.1. The robot performs the task without operator intervention, with the help of remote control, according to the conditions:

- If the robot performs the overturn using the manipulator or similar devices, the team is qualified in the Manipulator category.
- If the robot performs the overturn only using its basic running gear (for example, when hit against the wall), the team is not qualified in the Manipulator category. This is also the case when the robot overturns spontaneously, without control, only due to its design (e.g. rounded body).

11.5.2. 120 points will be awarded for completion.

11.6. **Autonomous overturn**

11.6.1. The overturn is counted if the robot performs the task automatically, without operator intervention and without the use of remote control, and with the help of sensors to determine the position of the robot in space - the team is awarded in the Autonomy category.

11.6.2. 240 points will be awarded for completion.

11.6.3. Before starting an attempt, the team must warn the judge that they are going to carry out the overturn autonomously.

11.7. **Task completion options**

11.7.1. First option: the robot can start the attempt by performing this task, right on the "start" field. In this case, the robot must be tilted on its side in the starting position or turned upside down by the participant himself. The execution of the task starts after the attempt time starts.

11.7.2. To execute an autonomous overturn, the robot can be tilted on its side or manually turned upside down immediately after the "start" command. In this case, the operator can be assisted by team members.

11.7.3. Second option: the robot performs the task during the attempt. The robot can be tilted on its side or turned upside down only with the use of the remote control.

11.7.4. In both cases, if the robot is unable to complete the task and come to its initial position, the standard rules apply: the participant can take a penalty and intervene in the control (see "Penalties" section).

11.8. A judge evaluates the position of the robot (before and after the overturn).

11.9. An example of how to complete the task is shown in the video below. According to

the rules described above, it is a controlled overturn from the side, 120 points, qualification in the Manipulator category. https://www.youtube.com/watch?v=CBN5L8dGg8o&list=PLgasM8avUUwH7EjA92314qNTmbmZXkMqp&index=2&t=0s

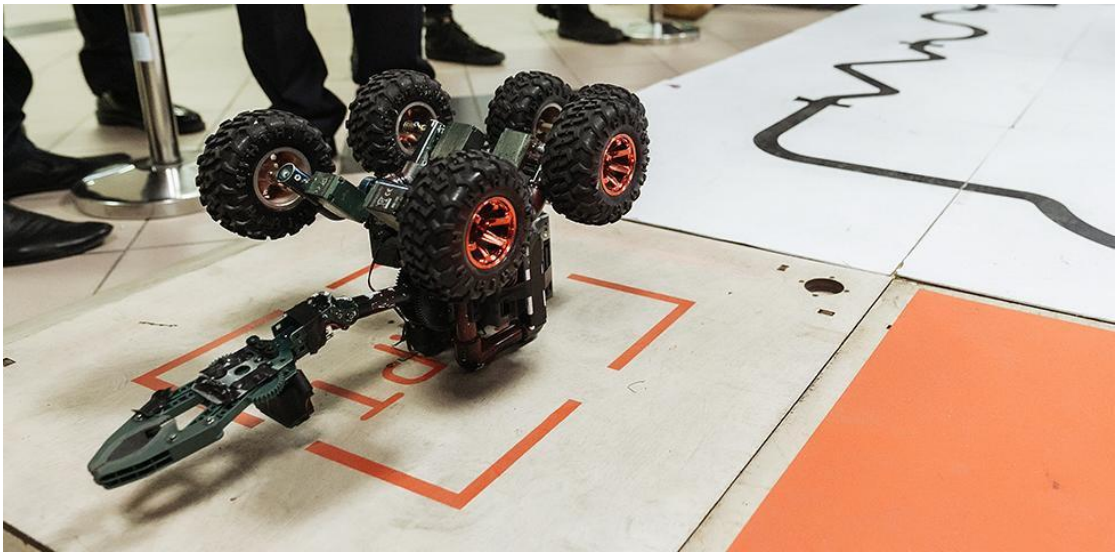


Figure 3 Overturn

12. Penalties and timing requirements

12.1. **If an attempt is postponed,** a penalty will be charged for the future result of the attempt (see Annex 2 "Points" to the current document). An attempt may be postponed only once.

12.2. **Penalty for interference in the control:**

12.2.1. In case the operator needs to interfere in the robot's work (the robot is stuck, hung, needs to be reloaded, needs to be repaired), the team will be charged a penalty. With the next intervention, the attempt is over. The repair time is limited to 5 minutes.

12.2.2. If the robot is stuck and cannot pass a cell, at the operator's request it is lifted and moved to the point of its entry in that cell, or to the previous cell. Such an action is counted as an intervention in the control and is subject to a penalty.

12.2.3. Only the judge can lift the robot, hand it over to the participant and put it in place during the attempt.

12.2.4. During the operator's intervention in the robot's work, the time is **not stopped** by the judge.

12.2.5. Time limit on task execution:

12.2.5.1. If the robot does not leave one cell within **2 minutes**, it is considered stuck. The participant is charged a penalty, or the attempt is over.

12.2.5.2. Outside the perimeter of the Maze and the Tower, the robot can stay no longer than

5 minutes (autonomous and coloured fields that are not in cubes are not considered part of the Maze).

12.2.5.3. If the robot is stuck/stays outside the perimeter afterwards, the countdown time (2/5 min) starts again.

12.2.5.4. The time for executing manipulator tasks is **not limited**, except for delivery of beacons (general rules apply for delivery - no more than 2 minutes in one cell of the Maze, no more than 5 minutes - outside of the perimeter).

12.2.6. Do not remove functional modules from the robot during repair (sensors, camera, manipulator, levers, wheels, tracks, motors). Individual small parts (clamps, tape, rubber bands, screws, and other fasteners) may be removed.

12.2.7. Any components of the robot can be removed or replaced during the break between attempts.

12.2.8. In case of repair, 2 minutes are counted again.

12.3. **Penalty for falling off parts:**

12.3.1. If the robot loses any part during the attempt, a penalty will be charged for each lost part, regardless of its size (debris and pieces of material, nut, beam, or entire module).

12.3.2. Any piece of the robot that is unable to move independently of it is considered a part.

12.4. **Penalty for enabling autonomous mode with a button located on the robot:**

12.4.1. Switching the autonomy on/off must take place remotely, and the participant must not touch the robot. In this case, the number of automatic mode switches is not limited.

12.4.2. A **penalty** is charged for enabling or disabling the autonomy using the button **located on the robot** (for the whole cycle: on/off). In this case, only 2 automatics on/offs are allowed.

12.5. **A penalty for tripping a mine**

12.5.1. The team is charged a penalty for running over a mine or activating a mine with any part of the robot.

12.5.2. The robot can intentionally demine by, for example, pressing an item on the mine. While doing so, the robot cannot touch the mine with any part during the mine clearance. The robot will be awarded for each cleared mine.

12.6. For **unsportsmanlike behavior** (non-compliance with moral and ethical standards, rude behavior towards other participants, organizers, and judges of the competition) punishment is disqualification by decision of the panel of judges

12.6.1. The number of penalty points is specified in Annex 2 "Points".

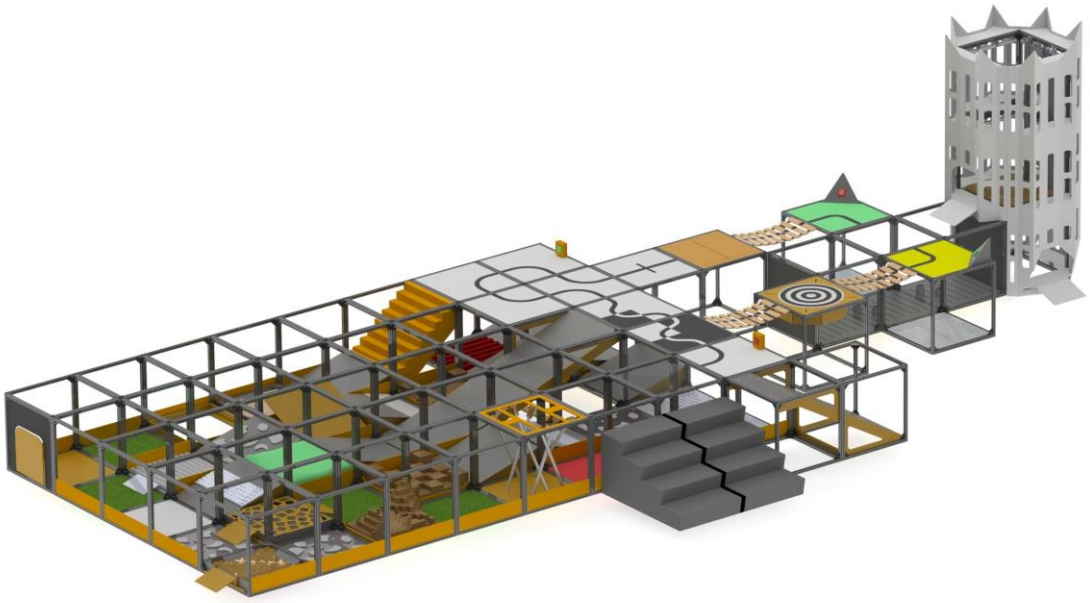
12.7. The panel of judges may impose additional restrictions.

13. Judging

13.1. At the end of the attempt, the robot operator signs the scorebook and thus accepts the results recorded therein.

13.2. The scorebook is an internal document for the competition and is used exclusively by the judges and organizers. The scorebook is not intended for use by the participants. It is forbidden to photograph or copy the scorebook.
13.3. Control and wrapping up are carried out by the panel of judges in accordance with the rules of the competition.
13.4. Discussion of the competitive process, schedule, and results of attempts with judges and organizers is carried out only with participants of teams and their leaders.
13.5. All appeals on the results are accepted in handwritten form by RTC Cup judges at the registration desk, within an hour after the results are announced (in writing in the competition area or on the competition website). On the same day, appeals are reviewed by a panel of judges, and participants receive a written reply.
13.6. All other points at issue during the competition shall be resolved on site by the panel of judges; all participants shall obey their decisions.

Appendix 1. Description of the Test Arena / tasks



1. 1 floor

1.1. The Door opening in both directions by 90 ° (towards and away from you) with a handle of the "rod" type. Overall dimensions of the door 480x480x8. To open the door from yourself / to yourself, an effort of 200 g (2 Newtons) is required, because in the zero position, the door is held by magnets located on the door jamb and at the end of the door opposite each other.
The height of the door handle above the floor is 220 mm, the thickness of the handle is 8 mm, and the length is 110 mm. Handle material - metal.

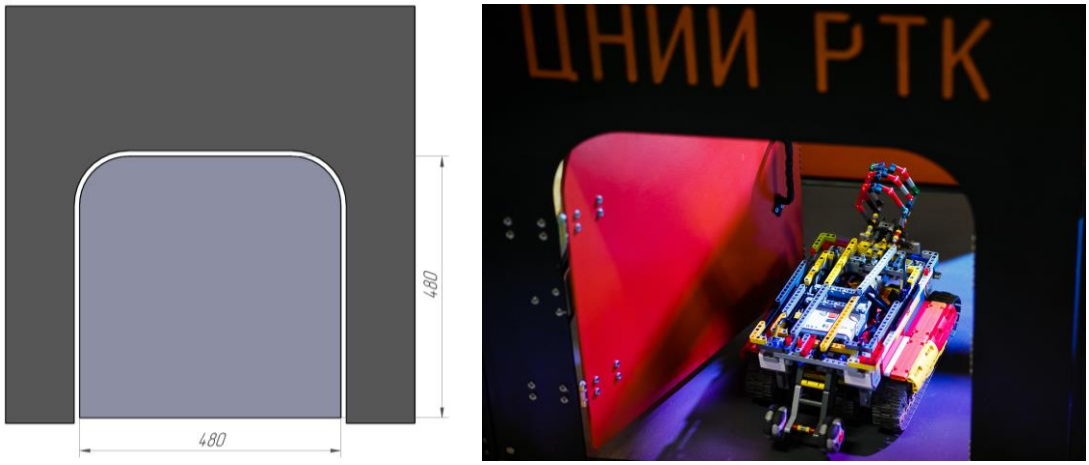
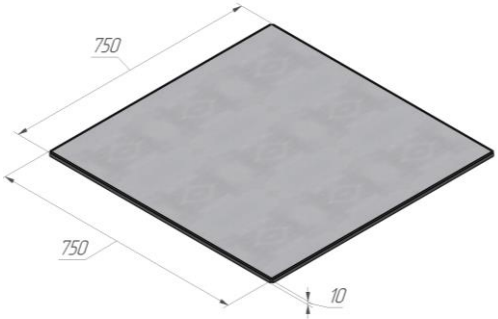


Figure 1. Door

Tasks:
Open the door towards yourself or away from you (in the second case, you must bring the door to the "open" position at an angle of 90 °).
Objectives:
The door is intended to demonstrate either the accuracy or functionality of the manipulator or the maneuverability of the robot.
Rationale:
Simulation of opening doors in buildings for further elimination of fires, explosions or explosion threats.

1.2. **Ice** is a slippery fluoroplastic tile attached to a plywood sheet (Figure 7). Plate dimensions are 740x740x10. Multipurpose lubricant WD-40 is applied on the surface to increase slipperiness.



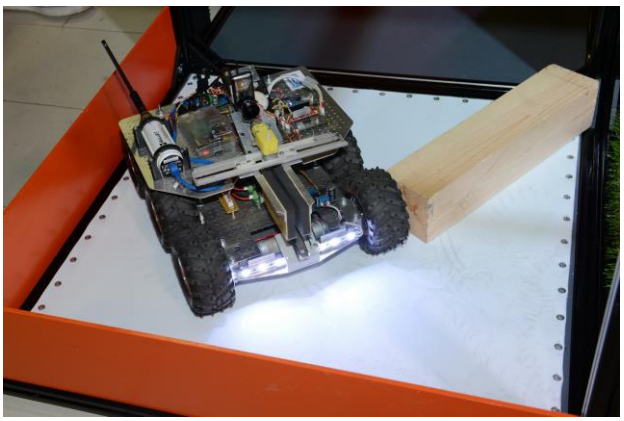


Figure 2. Ice

Tasks:
Overcome the challenge.
Objectives:
The ice is used to demonstrate the quality of the traction of the wheels / tracks of the robot with the surface.
Rationale:
Hydrometeorological emergency - severe ice.

1.3. The **Grass** is a sector with artificial grass made of polypropylene, the pile length is 40 mm. The coating is affixed to a plywood sheet. Sector dimensions are 740x740x50.

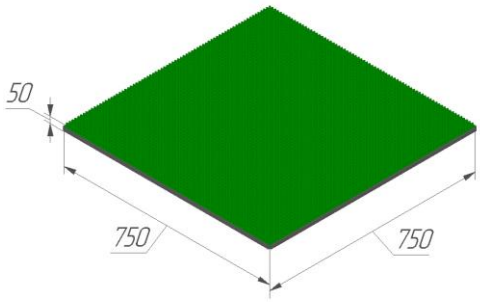


Figure 3. Grass Sector

Tasks:
Overcome the challenge.
Objectives:
Artificial grass is used to demonstrate the integrity and strength of the robot structure, as well as its passability in natural conditions.
Rationale:

Elimination of forest fires, fires of steppe and grain areas, peat fires, underground fires of fossil fuels.

1.4. **Stones** sector consists of plywood with pieces of broken stones attached to it. The stone pieces have sharp angles and significantly vary in height. The average height of stone layer is 40 mm. Sector dimensions are 740x740x50.

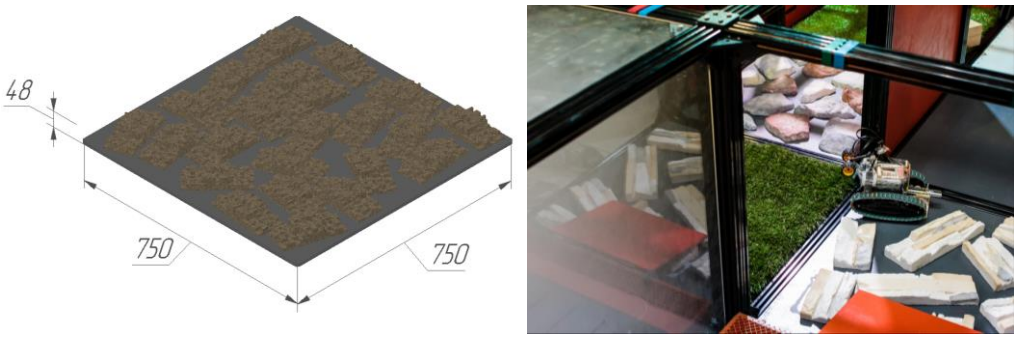


Figure 4. Stones Sector

Tasks:
Overcome the challenge.
Objectives:
The stone platform is designed to demonstrate the robot's patency, engine power and suspension capabilities.
Rationale:
Simulation of the consequences of a sudden collapse of buildings and structures.

1.5. Inclined surfaces with an **inclination angle of 15 °**, with overall dimensions 740x690x200.

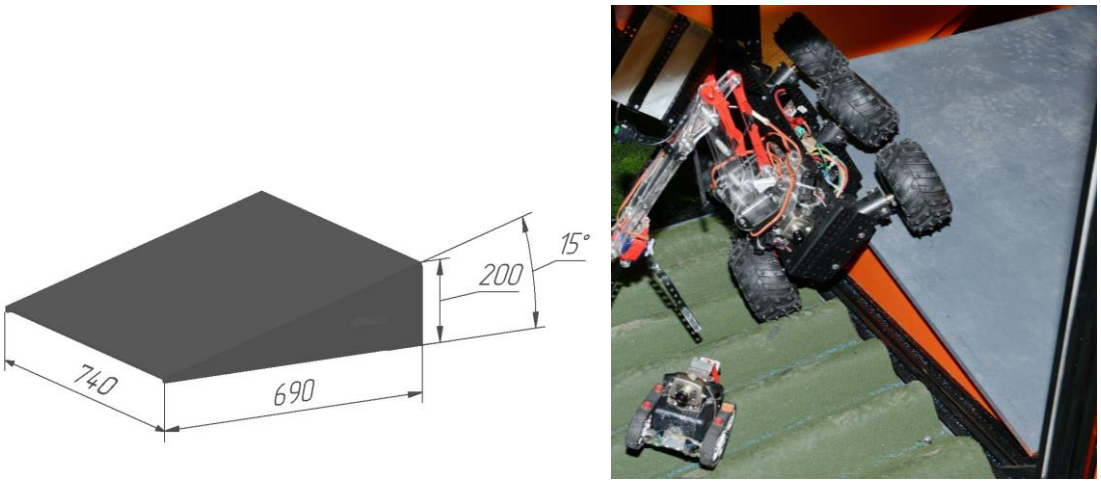


Figure 5. Inclined surface of the labyrinth 15 °

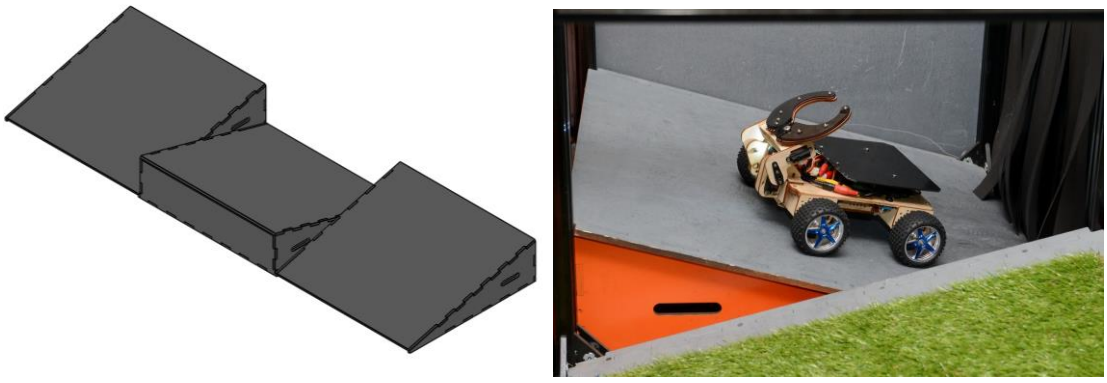


Figure 6. Possible inclined arrangement

Inclined with an angle of inclination of 20 °, with dimensions and 500 x250 x100. Attached to the boxes.

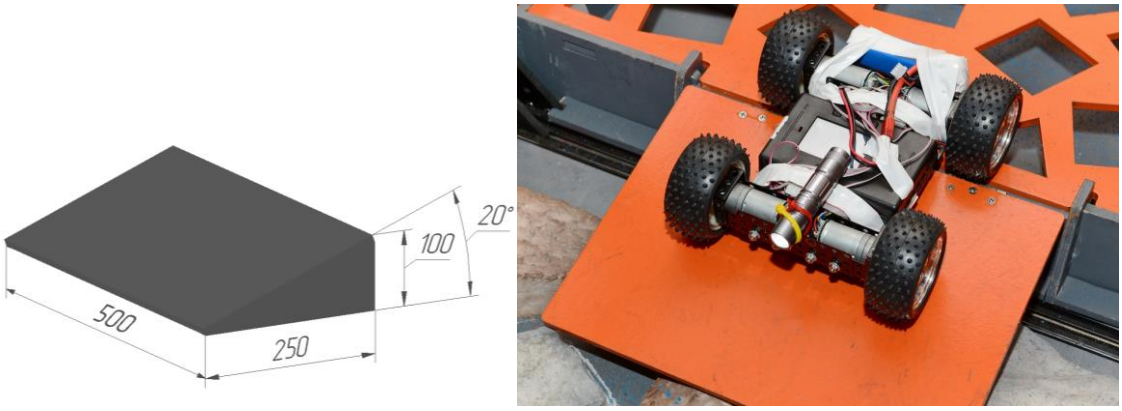


Figure 7. Inclined labyrinth surface 20 °

Tasks:

Go up or down the slope.

Objectives:

Demonstration of the balance of the center of gravity and the ability of the mobile robot to overcome inclined sections.

Justification:

Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.

1.6. The stone slide is an inclined 15 °, with dimensions of 740x690x200, on which the stones are fixed. The height of the stones is 15-40 mm.

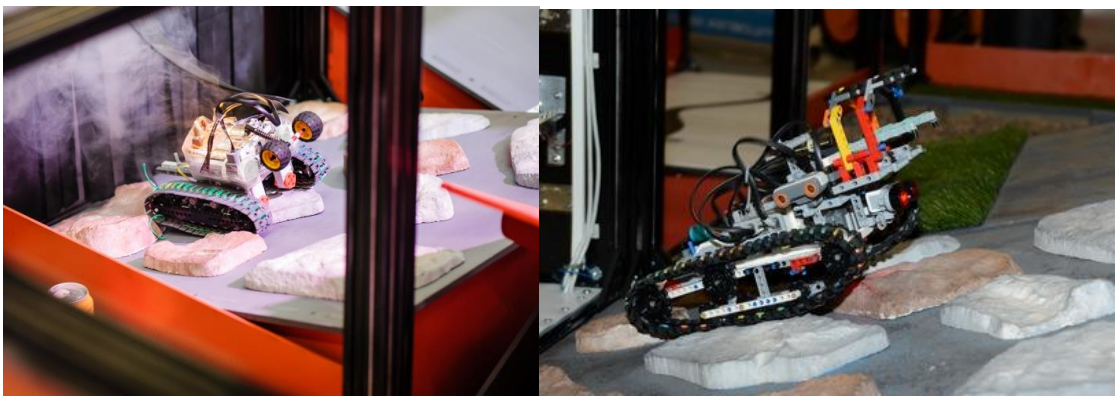


Figure 8. Stone slide

Tasks:

Overcome the challenge.

Objectives:

Demonstration of the robot's patency and the power of its motors, as well as its ability to overcome difficult terrain at an angle.

Rationale:

Simulation of the consequences of geological (exogenous geological) emergencies - landslides, mudflows, landslides, taluses, avalanches, slope washout, **subsidence** of loess rocks, subsidence (landslides) of the earth's surface.

1.7. Grass slide - is an inclined 15 °, with dimensions 740x690x200, on which a strip of artificial grass is fixed. Pile height - 40 mm. The width of the artificial grass can be varied, from 200 mm to the entire surface of the slope.

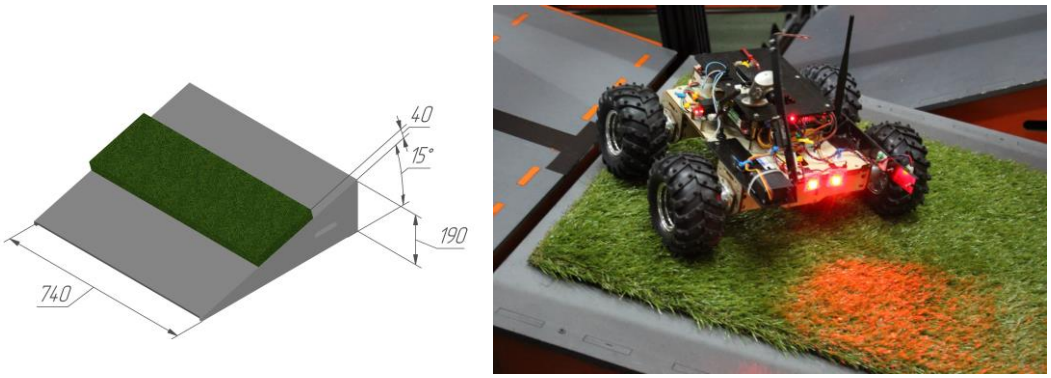


Figure 9. Grass slide

Tasks:

Overcome the challenge.

Objectives:

Demonstration of the traction and power of the robot's motors, as well as its ability to overcome difficult terrain at an angle.

Rationale:

Elimination of forest fires, fires of steppe and grain areas, peat fires, underground fires of fossil fuels.

1.8. Gable narrow slide 15 ° grass / stones - is a gable inclined 15 °, with dimensions 420x690x160, on which a strip of artificial grass and stones is fixed. The pile height is 15 mm, the dimensions of the stones are arbitrary, but the height of the stone is no more than 40 mm. The width of the side openings along the edges of the slide is 163 mm (including the profile).

Figure 10. Gable narrow slide 15 ° grass / stones

Tasks:

Overcome the challenge. Overcoming the cell is counted only for a complete ride over the hill.

Objectives:

Demonstration of the traction and power of the robot's motors, as well as its ability to overcome difficult terrain at an angle.

1.9. The pool with tennis balls is a section that is a triangular depression made up of two inclined 15 °. 300 plastic ping-pong balls (diameter 40 mm) are

poured into the recess. Inclined dimensions are standard - 740x690x200. The depth of the layer of balls ranges from 40 to 100 mm.

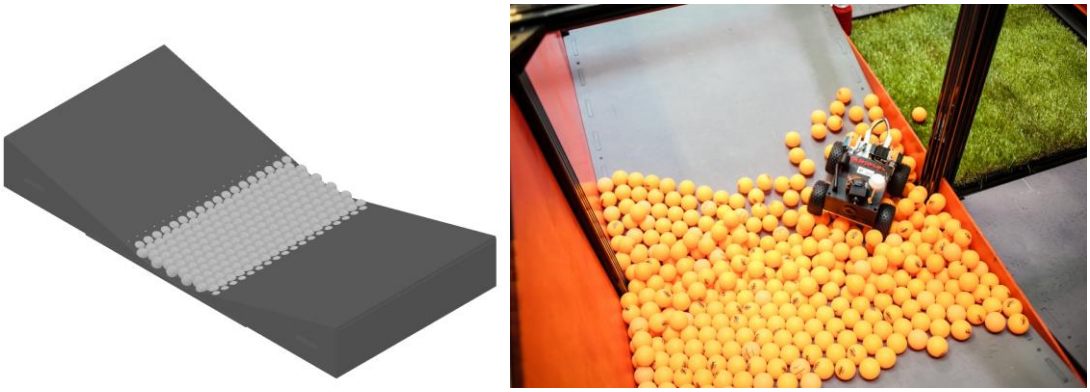


Figure 11. The pool with tennis balls

Tasks:

Overcome the challenge.

Objectives:

This section serves to demonstrate the high traffic of the robot. To pass this test, high maneuverability and good robot control skills are also required.

Rationale:

The consequences of hydrodynamic accidents are dam breaks (dams, sluices, bridges) with the formation of breakthrough waves and catastrophic flooding.

1.10. Sand - an area that is a box filled with quartz sand (particle size 0.2-2.5 mm). Box dimensions 720x720x100. The height of the sand layer varies between 20-30 mm. Inside the box there are inclined ramps, outside, inclined surfaces are attached to the box.

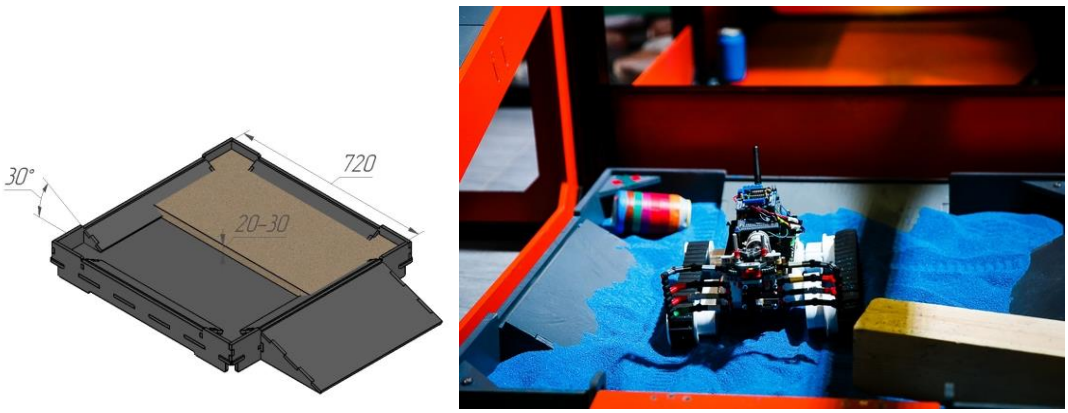


Figure 12. Sand

Tasks:

Overcome the challenge.

Objectives:

A sandy area is necessary to demonstrate the permeability on crumbling surfaces, the strength of the robot, and its susceptibility to breakdowns under the influence of external stimuli.

Rationale:

Simulation of the consequences of geological (exogenous geological) emergencies - landslides, mudflows, landslides, taluses, avalanches, slope washout, subsidence of loess rocks, subsidence (landslides) of the earth's surface.

1.11. Cones - an area that is a box filled with spruce and pine cones. Inclined ramps are equipped inside the box, inclined surfaces are attached to the box outside.

Figure 13. Cones

Tasks:

Overcome the challenge.

Objectives:

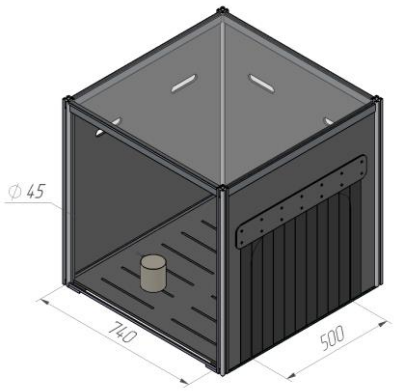
The site is necessary to demonstrate the patency on crumbling surfaces, the strength of the robot, and its susceptibility to breakage under the influence of external stimuli.

Rationale:

Simulation of the consequences of geological (exogenous geological) emergencies - landslides, mudflows, avalanches, talus, avalanches, slope washout, subsidence of loess rocks, subsidence (landslides) of the earth's surface.

1.12. Fog is an area with heavy smoke. It consists of several connected sections (2-3 cells), with a plywood floor (8 mm thick) and walls made of transparent plexiglass and plywood. The sections have entrances (arched openings

500x500, curtained with rubber strips 50 mm wide). Smoke is generated by a smoke machine installed inside one of the sections. Obstacles are randomly screwed to the floor of the sections - plexiglass cylinders with a diameter of 100 mm (6-8 pcs). The passage width between the cylinders is at least 350 mm.



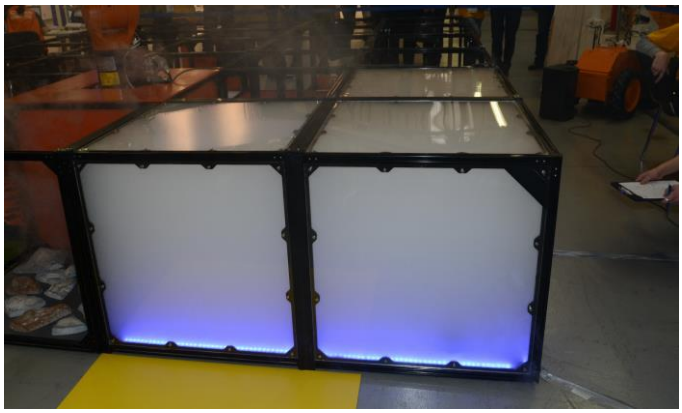


Figure 14. Fog

Tasks:

Overcome the challenge by avoiding obstacles. It is allowed to install flashlights, headlights and other means to improve visibility on the robot.

Objectives:

This section is used to assess the ability of the robot to navigate and maneuver in conditions of reduced visibility.

Rationale:

Simulation of a hydrometeorological emergency - fog, as well as natural fires and fires (explosions) in buildings, communications and technological equipment of industrial facilities.

1.13. The button is an ordinary household switch for a light bulb. When pressed, the LED strip on the "Fog" section lights up. The button is located at a

height of no more than 70 mm from the floor. When this button is pressed by the manipulator, the attempt is counted.

Figure 15. The button

Tasks:

Press the button in any way.

Objectives:

The button is used to demonstrate the properties of the robot manipulator: accuracy, effort, range.

Rationale:

Simulation of work in emergency conditions in buildings, on communications and technological equipment of industrial facilities.

1.14. Expanded clay - a section that is a box filled with expanded clay, with a particle size of 10-20 mm. Box dimensions 720x720x100. The height of the expanded clay layer ranges from 20-30 mm. Inside the box there are inclined ramps, outside, inclined surfaces are attached to the box.

Figure 16. Expanded clay

Tasks:

Overcome the challenge.

Objectives:

This section is necessary to demonstrate passability on crumbling surfaces.

Rationale:

Simulation of the consequences of a sudden collapse of buildings, structures, as well as the consequences of geological (exogenous geological) emergencies - landslides, mudflows, landslides, debris, avalanches, slope washout, subsidence of loess rocks, subsidence (landslides) of the earth's surface.

1.15. Mesh - this section is a frame with dimensions of 740x740 mm. The mesh is stretched on the frame. The mesh sags slightly due to the weak tension. The mesh size in the grid is 1 cm2. The mesh material is a thin nylon cord, the weaving is nodular.

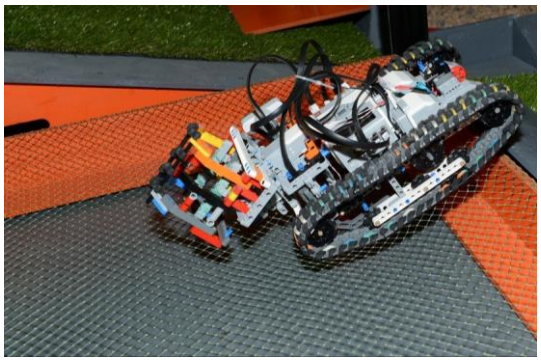


Figure 17. Mesh

Tasks:

Overcome the challenge.

Objectives:

Passing this section reveals structural defects of the robot: protruding, clinging parts, poorly distributed weight.

Rationale:

Simulation of the consequences of a sudden collapse of buildings and structures for residential, social and cultural purposes, collapse of elements of transport communications.

1.16. Quagmire - a polyester bag filled up to half with polystyrene balls of 4-6 mm fraction is placed in the cell.

Figure 18. Quagmire

Tasks:

Overcome the challenge.

Objectives:

In this area, the robot demonstrates its permeability in a viscous environment.

Rationale:

Simulation of the consequences of an accident on communal life support systems, as well as the consequences of hydrodynamic accidents - breakthroughs of dams (dams, sluices, bridges) with the formation of breakthrough waves and catastrophic flooding.

1.17. The sieve is a lattice with holes of various shapes, 70-80 mm in diameter.

Figure 19. The sieve

Tasks:
Overcome the challenge.
Objectives:

Demonstration of the robot's patency, engine power and suspension capabilities

Rationale:

Simulation of the consequences of geophysical emergencies - earthquakes, volcanic eruptions.

1.18. Roof - a section, which is a piece of roofing sheet (ondulin), fixed on a plywood platform. Overall dimensions of the test - 740x740x40.

Figure 20. Roof

Tasks:

Overcome the challenge.

Objectives:

Demonstration of the robot's patency, engine power and suspension capabilities.

Rationale:

Simulation of the consequences of geophysical emergencies - earthquakes, volcanic eruptions, as well as sudden collapse of buildings and structures.

1.19. Swing - plywood, fixed on an axis passing in the middle of the cube-cell. The swing is located at a standard inclined 15 ° height. The maximum swing angle is about 30 °.

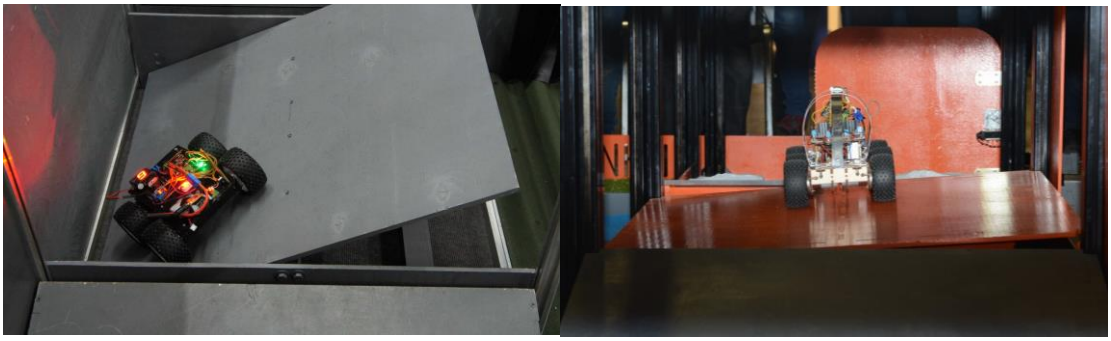


Figure 21 Swing

Tasks:

To overcome the test from one incline to another, for which you need to drive exactly along the axis, keeping balance.

Objectives:

This obstacle demonstrates the responsiveness of the robot and the skill of the operator.

Rationale:

Simulation of the consequences of geophysical emergencies - earthquakes, volcanic eruptions, as well as sudden collapse of buildings and structures.

1.20. The hoof is a structure representing a sharp rise (30 °), turn and descent (30 °). The obstacle is covered with carpet for better traction on the ascent and descent. Lift height - 200 mm.

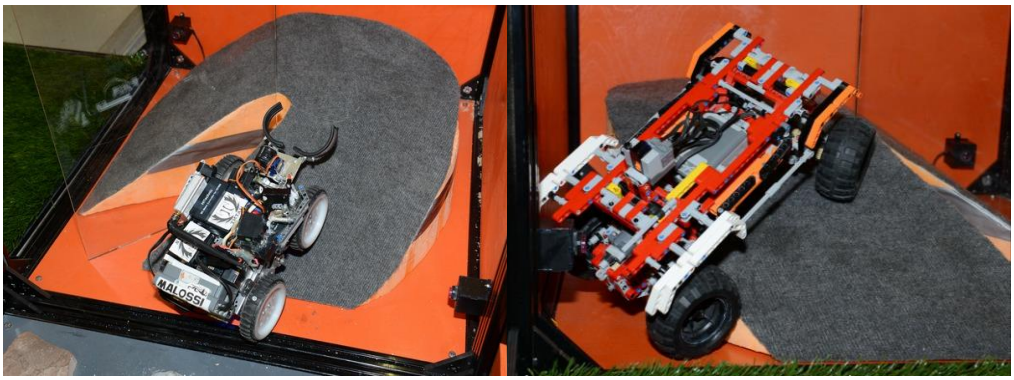


Figure 22. The hoof

Tasks:

Overcome the challenge. The test can be either fenced off with walls to restrict the movement of the robot exclusively along the entire length of the bend, or not fenced at all. In the second case, the robot can act as in the case of standard tests: enter from one side of the cell and exit from it from either side.

Objectives:

The obstacle allows you to assess the maneuverability of the robot, its balance and moment on the wheels.

Rationale:

Simulation of the consequences of geophysical emergencies - earthquakes, volcanic eruptions, as well as sudden collapse of buildings and structures.

1.21. Gullies - a construction of 50x50mm wooden blocks of different lengths, installed vertically, tightly to each other The test is housed in one standard 800 mm high cube.

Figure 23. Gullies

Tasks:

Overcome the challenge.

Objectives:

The passage of such a surface demonstrates the patency of the robot and the power of its motors, as well as its ability to overcome difficult terrain.

Rationale:

- • Simulation of the consequences of geological (exogenous geological) emergencies - landslides, mudslides, landslides, talus, avalanches, slope washout, subsidence of loess rocks, subsidence (landslides) of the earth's surface.
- • Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.

1.22. Rollers - the floor of the cube is a roller conveyor made of polypropylene pipes mounted on bearings. The pipes rotate around their axis, making it difficult for the robot to move.

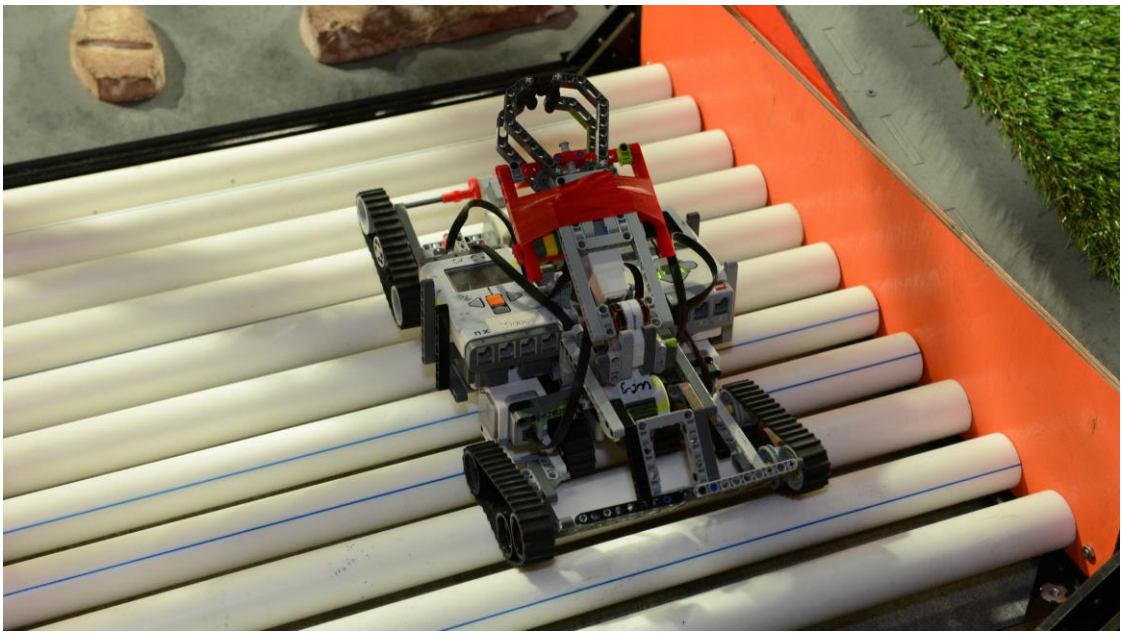


Figure 24. Rollers

Tasks:

Overcome the challenge.

Objectives:

The rollers test the passability of the robot and the power of its motors.

Rationale:

Hydrometeorological emergency - severe ice.

1.23. Blockage - the test is a standard polygon cube, the lid of which is cut out of plywood, to which multidirectional polypropylene pipes are attached using metal card loops. Thus, the pipes block the path through the cube.

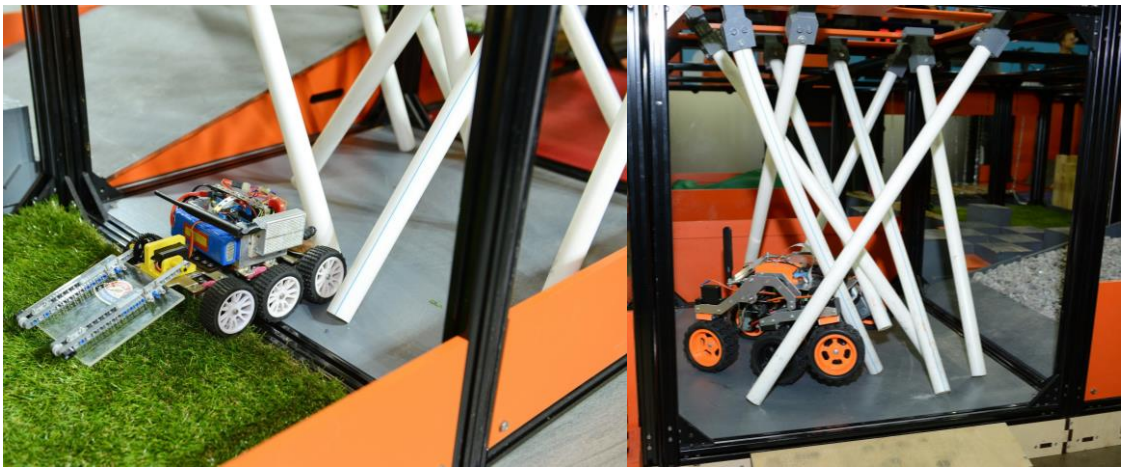


Figure 25. Blockage

Tasks:

Overcome the test by pushing the pipes in different ways: by the robot body or by the manipulator.

Objectives:

The blockage tests the robot's patency, the power of its motors, the structural strength and the functionality of the manipulator.

Rationale:

Simulation of work in emergency conditions in buildings, communications and technological equipment of industrial facilities.

1.24. Straight ramps are a standard cube filled with boxes of different heights, with a height difference of 50mm.

Figure 26. Straight ramps

Tasks:

Overcome the challenge.

Objectives:

Checks the patency of the robot.

Rationale:

• Simulation of the consequences of a sudden collapse of buildings and structures for residential, social and cultural purposes, collapse of elements of transport communications.

• Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.

1.25. Oblique ramps are a standard cube filled with boxes with an angle of inclination of 15 °, of different directions.

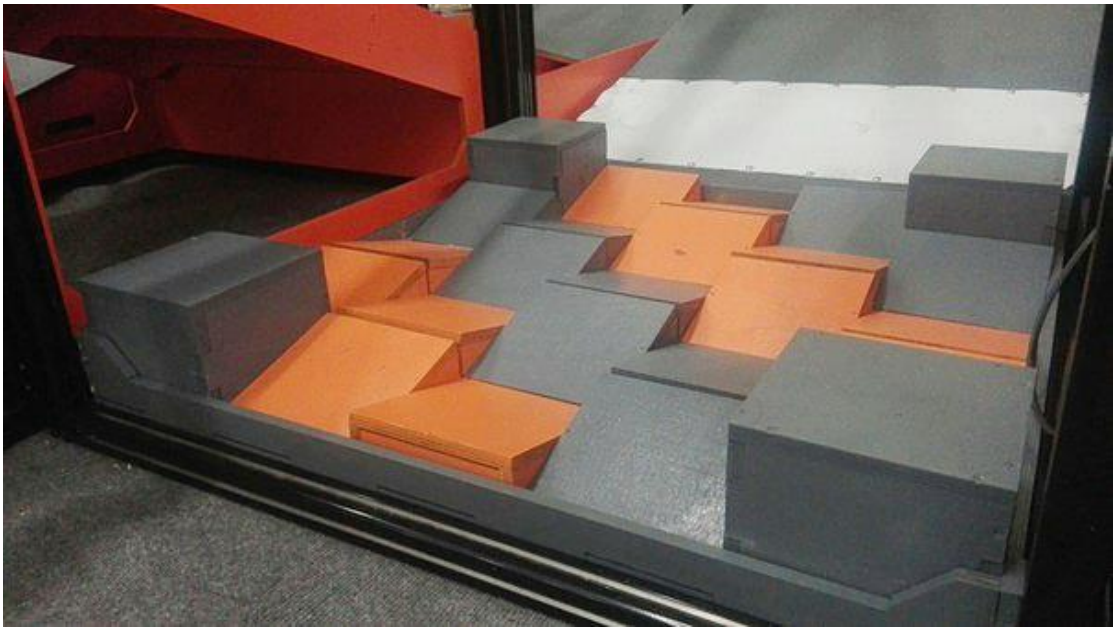


Figure 27. Oblique ramps

Tasks:

Overcome the challenge.

Objectives:

Checks the patency of the robot.

Rationale:

• Simulation of the consequences of a sudden collapse of buildings and structures for residential, social and cultural purposes, collapse of elements of transport communications.

• Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.

1.26. Oblique ramps-2 is a standard cube filled with boxes with an inclination angle of 15 °, of different directions. Ramps of different heights with a height difference of 50 mm.

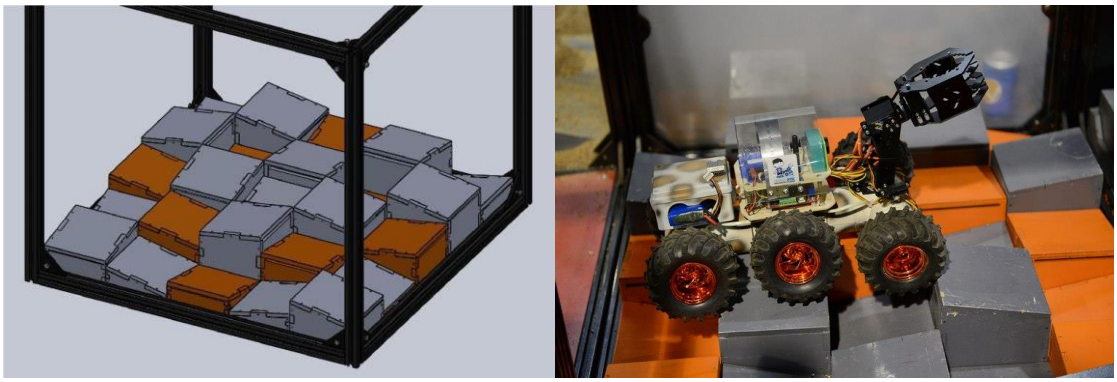


Figure 28. Oblique ramps-2

Tasks:

Overcome the challenge.

Objectives:

Checks the patency of the robot.

Rationale:

• Simulation of the consequences of a sudden collapse of buildings and structures for residential, social and cultural purposes, collapse of elements of transport communications.

• Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.

1.27. Inclined with oblique ramps - is a standard 15 ° inclined, with dimensions of 740x690x200 mm, filled with boxes with an inclination of 15 °, of different directions. Ramps of different heights with a height difference of 50 mm.

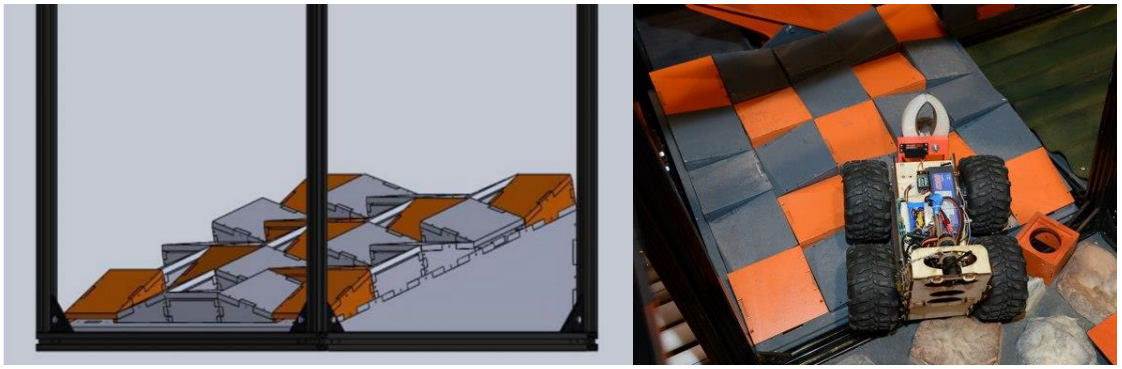


Figure 29. Inclined with oblique ramps

Tasks:

Overcome the challenge.

Objectives:

Checks the robot's patency, as well as its ability to negotiate difficult terrain at an angle.

Rationale:

• Simulation of the consequences of a sudden collapse of buildings and structures for residential, social and cultural purposes, collapse of elements of transport communications.

• Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.

1.28. Loose slide - is a standard 15 ° inclined, with dimensions of 740x690x200 mm, on which a box with plywood ribs is fixed to prevent the contents from shedding. The depth of the box is 40 mm. The box is filled with sand, expanded clay or gravel.

Figure 30. Loose slide

Tasks:

Overcome the challenge.

Objectives:

This section serves to demonstrate the high cross-country ability of the robot and the power of its motors.

Rationale:

Simulation of the consequences of geological (exogenous geological) emergencies - landslides, mudflows, avalanches, talus, avalanches, slope

washout, subsidence of loess rocks, subsidence (landslides) of the earth's surface.

1.29. Spikes - this area is a standard polygon cube with a platform on which the pieces of the timber cut at an angle are fixed. Thorn edge length - 70mm, edge width - 50mm, height - 50mm.

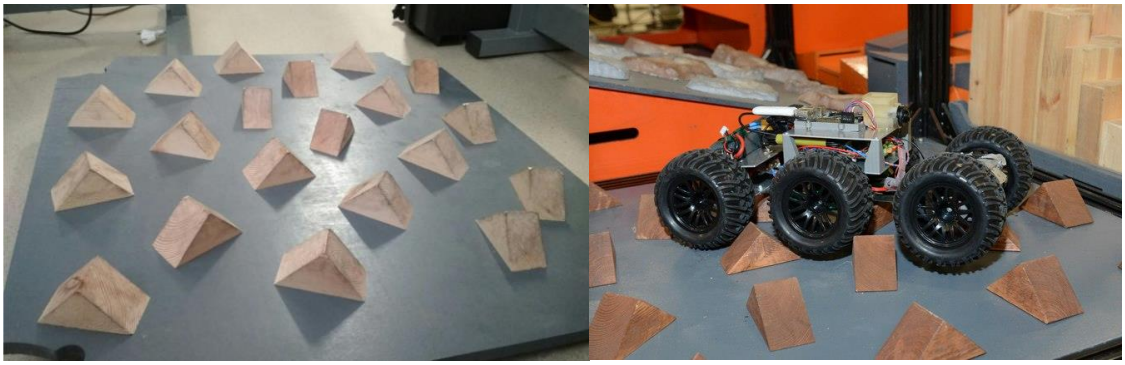


Figure 31. Spikes

Tasks:

Overcome the challenge.

Objectives:

This obstacle demonstrates the patency of the robot.

Rationale:

• Simulation of the consequences of a sudden collapse of buildings and structures for residential, social and cultural purposes, collapse of elements of transport communications.

• Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.

1.30. Stairs with pipes - The test is a standard polygon cube with plywood stairs inside. Rotating PVC pipes are built into the edges of the steps. The height of the first step is 32mm, the height of the second step is 40mm, the height of the third step is 72mm, the length of the step (from pipe to pipe) is approximately 320mm.

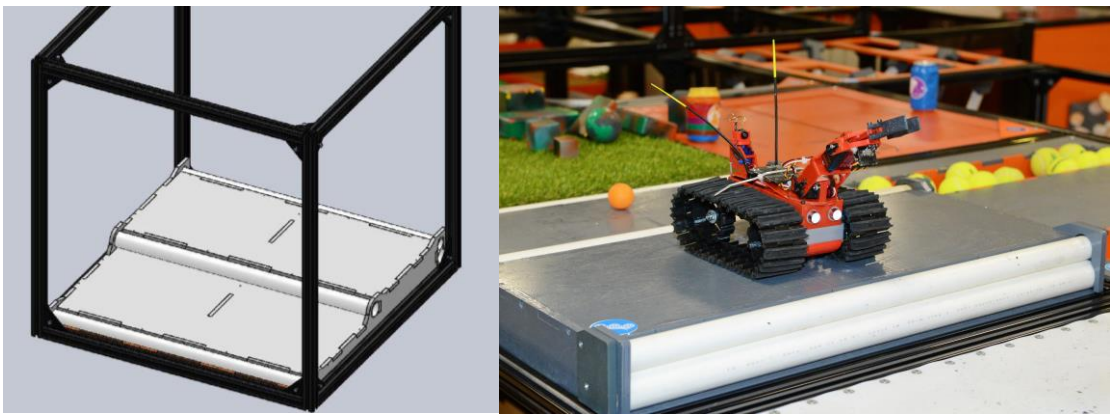


Figure 32. Stairs with pipes

Tasks:
Overcome the challenge.
Objectives:
The rungs with pipes test the robot's patency and the power of its motors.
Rationale:
Hydrometeorological emergency - severe ice.

1.31. Rails - The test is a standard polygon cube with a plywood platform in which rows of holes are made on two opposite sides. Screws are inserted into the holes protruding from two bars. The section of the timber from which the rails are made: 70x70 mm. The width of the rail is adjusted to the width of the robot base before the start. Access to the rails - either from the box or from a slight slope.

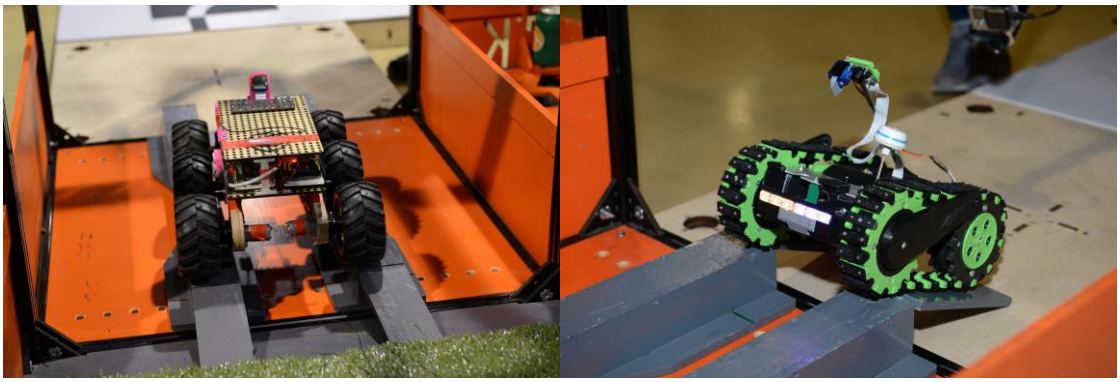


Figure 33. Rails

Tasks:
Overcome the test by driving exactly along the rails without touching the area on the cell floor.

Objectives:

This test is intended to demonstrate the maneuverability of the robot and the operation of the motor encoders.

Rationale:

Simulation of work in emergency conditions in buildings, communications and technological equipment of industrial facilities.

1.32. Logs - the test is a bridge made of planks. The width of one plank is 65 mm, the distance between the planks is 35 mm.

All planks of the bridge are connected by a chain and move apart to a width of no more than 65 mm. The width of the bridge is 500 mm. The height of the bridge relative to the cube floor is 80 mm. Check-in is carried out from a box or with a special attached inclined.

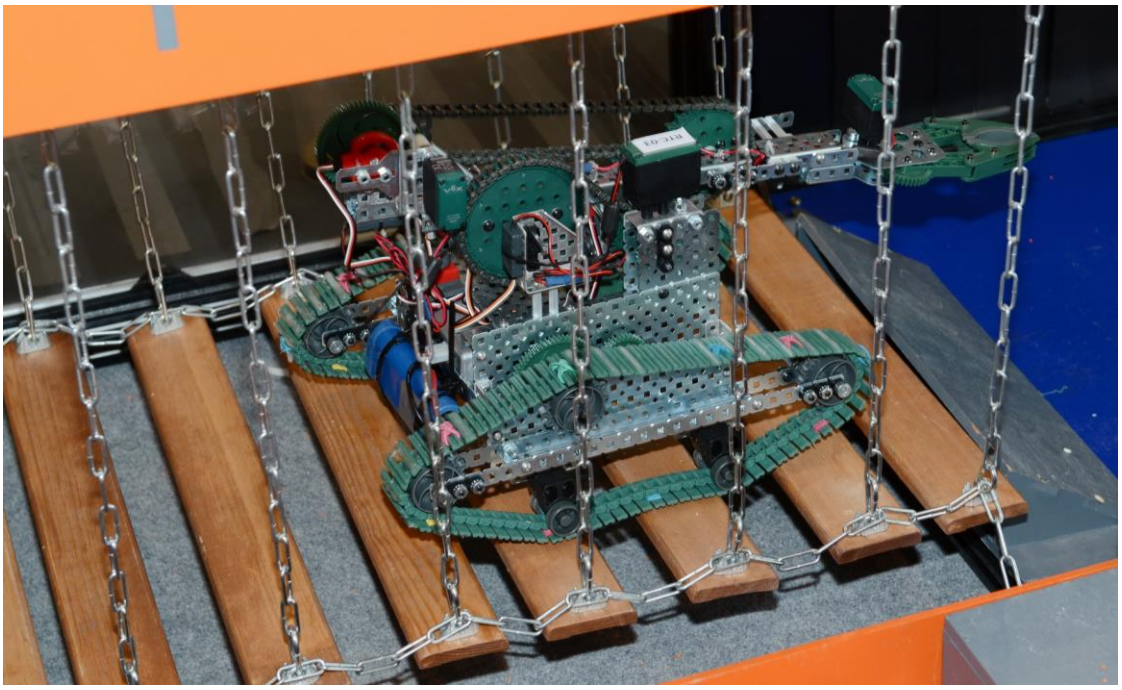


Figure 34. Logs

Tasks:

Overcome the challenge.

Objectives:

This test is intended to demonstrate the robot's patency on variable geometry surfaces and its suspension capabilities.

Rationale:

Simulation of work in emergency conditions in buildings, communications and technological equipment of industrial facilities.

1.33. Broken Road - The test is a standard landfill site with holes and fixed prefabricated plywood blocks. Blocks can be of various shapes: round and

triangular prism, parallelepiped. Edge length - 70mm, edge width - 50mm, spike height - 50mm. Hole width up to 120 mm.

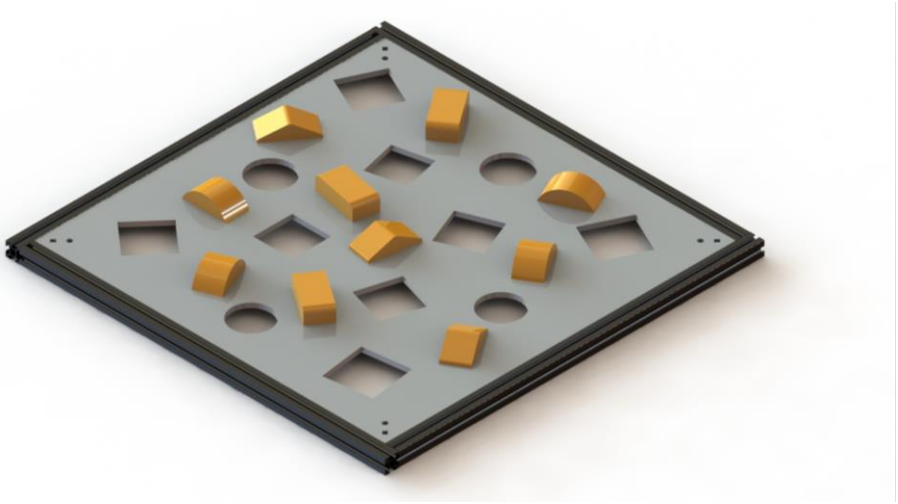


Figure 35. Broken Road

A task:
Overcome the challenge.
Goal:
Demonstration of the cross-country ability and maneuverability of the structure, testing the characteristics of the chassis, ground clearance and suspension.
Rationale:
Simulated broken road.

1.34. Ravine - Test is a layered plywood structure whose layers form two elevations. The height of the projections is 70 and 50 mm. The spacing between layers is 5 mm.

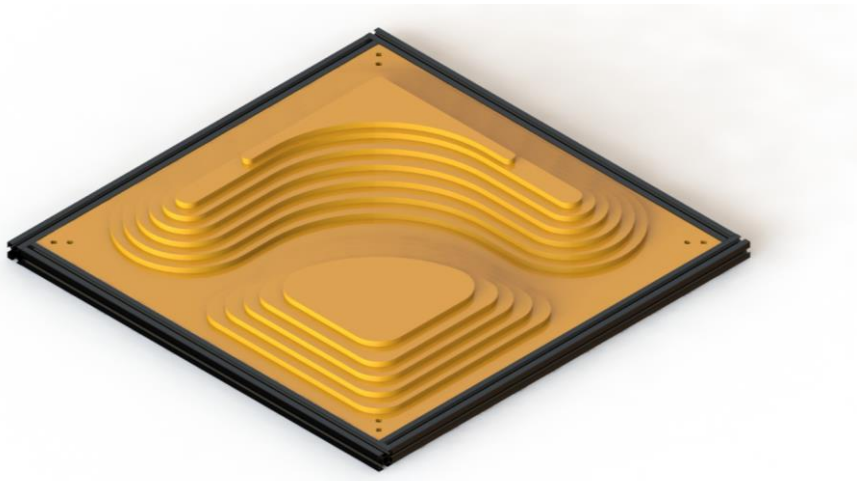


Figure 36. Ravine

A task:
Overcome the test (drive through the ravine).
Goal:
Demonstration of high cross-country ability and balance of the robot.
Rationale:
Natural ravines, hummocks, forest landscape.

1.35. Pit - Test is a plywood construction in layers, the layers of which form two recesses. The depth of the depressions is 70 and 50 mm. The spacing between layers is 5 mm.

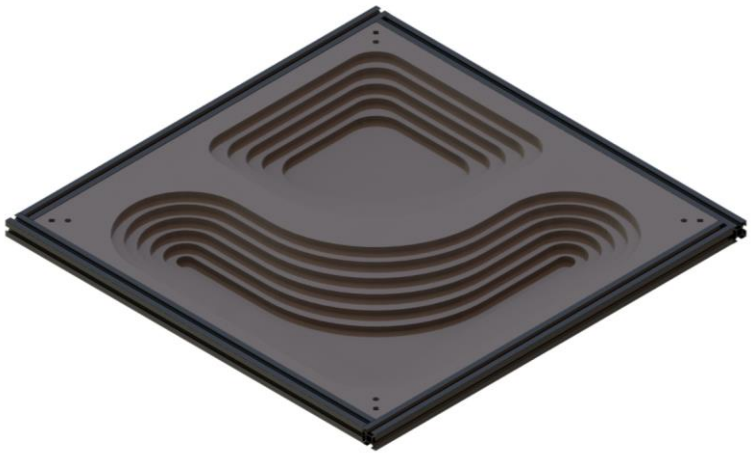


Figure 37. Pit

A task:
Overcome the test (drive through the hole). Passage is possible both along the tops of elevations (a turn is made), and in any direction. The scores for different coping methods differ.
Goal:
Demonstration of high cross-country ability and balance of the robot.
Rationale:
Natural ravines, pits, forest landscape.

1.36. Forest - Test is a standard polygon area covered with artificial grass. Artificial grass structures imitating trees (bushes) are randomly located on the site. The maximum diameter of the grass circle is 150 mm, the maximum height of the typesetting unit is 110 mm.

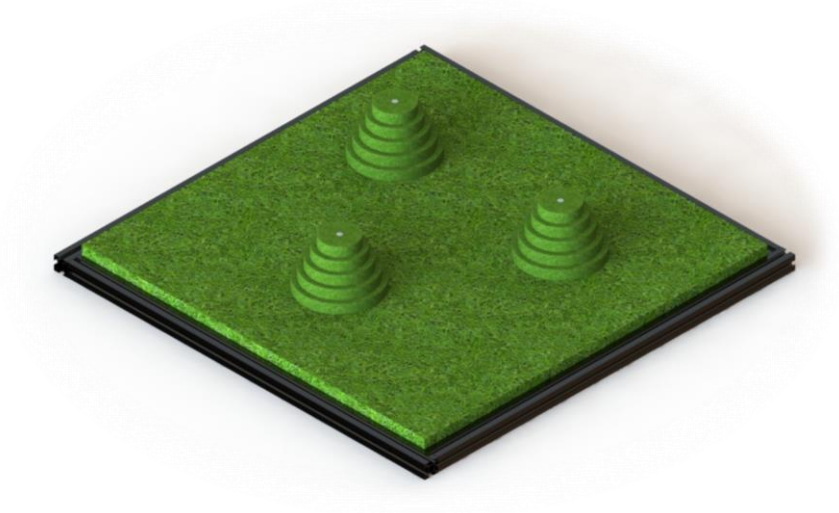


Figure 38. Forest

A task:
Overcome the test, if possible, bypassing the hills (drive through the forest).
Goal:
Demonstration of the maneuverability and patency of the robot.
Rationale:
Cross-country driving, through thickets, forest.

1.37. Box with sand / expanded clay / wires - the test is a plywood box with a depth of 40 mm, filled with various bulk materials.

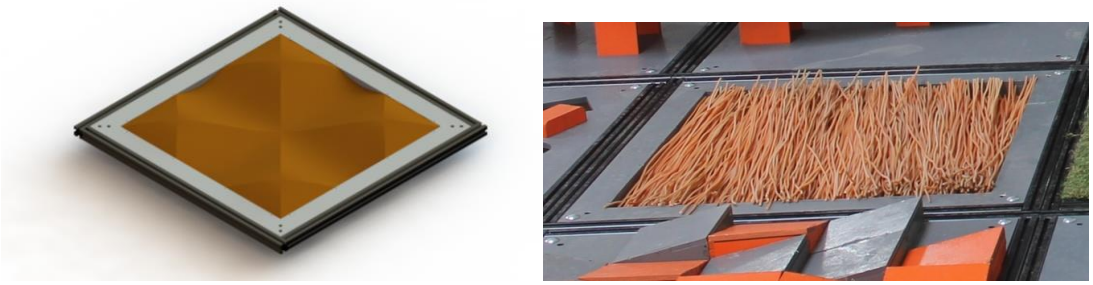


Figure 39 Box with filler

Task:
Overcome the challenge.
Objective:
Demonstration of high cross-country ability of the robot, test of chassis characteristics.
Rationale:
Driving on various crumbling surfaces: on construction sites, in the forest. Moving around in rooms in a mess (tangled wires on the floor)

1.38. Inclined ramps Agro - test is a standard landfill site filled with 15 ° inclined ramps of different directions. Ramps of different heights with a difference of 50 mm.

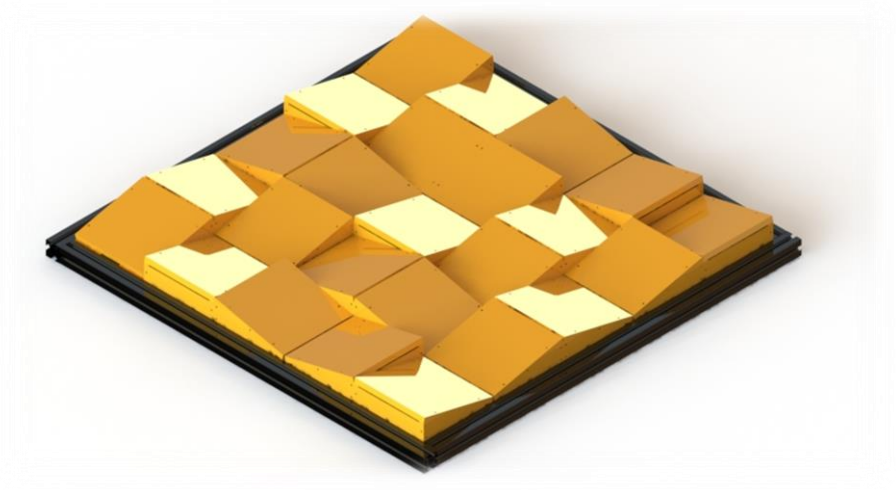


Figure 40 Dumping boards.

Task:
Overcome the test (drive through the board dump).
Objective:
Demonstration of the structure's patency and maneuverability.
Rationale:
Traffic on construction sites, in warehouses (board dump).

1.39. QR codes are a task that involves using a video camera or a robot camera. Available for execution only in the "Extreme" category.

The QR code sizes are from 50 to 120 mm. The code contains from 1 to 9 words encrypted. The codes are printed on sheets of paper and are located at various heights (50-200 mm) throughout the Labyrinth.
The decoded information can be used by the participant at his discretion, as an additional advantage (for example, doubling points for capturing red beacons), which is reflected in the points scored for the attempt.
It does not matter when the QR code was read - before or after performing an action that gives an advantage (for example, capturing a red beacon).In addition, the participant receives points for reading the code.

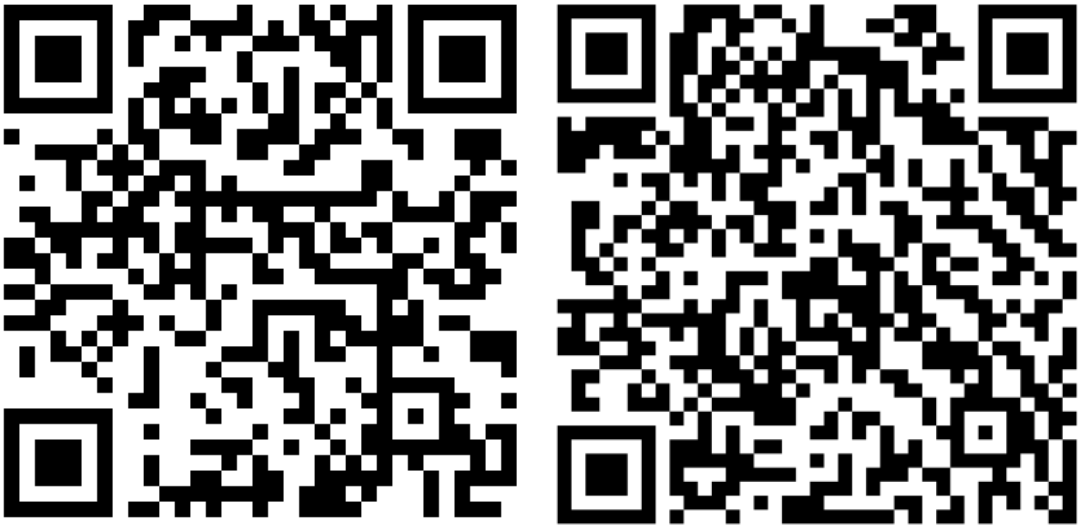


Figure 41 Examples of using QR codes

Tasks:

Hover over the QR code of the robot's camera and recognize it. There are two options: recognition by a robot (with the display of a QR code on the operator's screen), or recognition using an application on a smartphone (in this case, the code is read from the operator's screen).

When performing this task, in the first way, an additional, testing QR-code can be given to check the operation of the robot's QR-scanner. If the test fails, the task result will be canceled.

When the robot reads the code using a program running in the background, the launch counts as autonomous.

Objectives:

Evaluation of the quality characteristics of the camera and video communication of the robot, its maneuverability when searching for the optimal position for reading. Development of robot video vision programming skills.

Rationale:

Recognition of signs, signs, obtaining information about the environment.

1.40. Danger signs are a task that involves using the robot's video vision. Available for execution only in the "Extreme" category.The dimensions of the sign are 100x100 mm. Task: to recognize and identify the sign, as a result - the text of the sign should appear on the screen, and the sign itself should be highlighted on the screen (for example, highlighted by a frame).

When a robot reads a character using a program running in the background, the task is counted as autonomous.

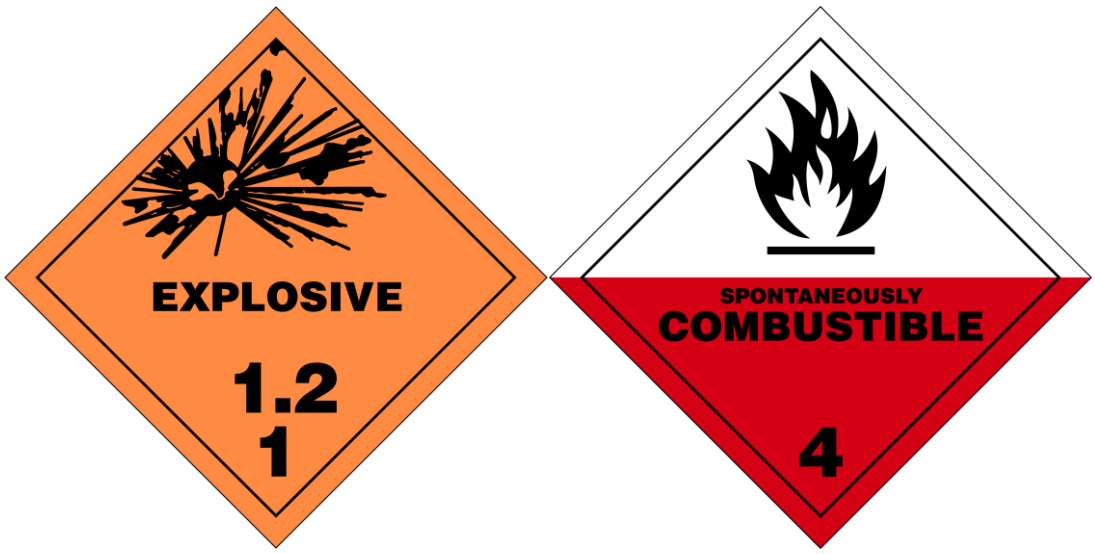


Figure 42 Example of danger signs

The document, supplying a complete list of marks for printing, can be found on the website of the RTC Cup at the link:
https://cup.rtc.ru/rtccup/reglament

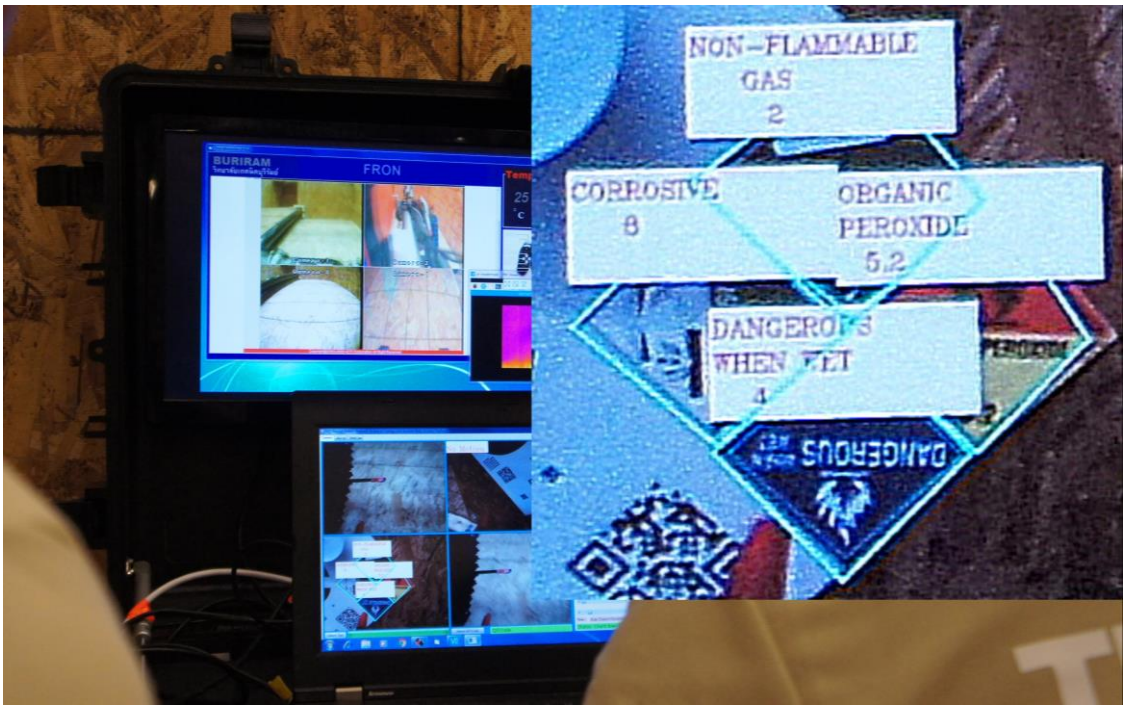


Figure 43 Example of reading danger signs

Objectives:

Evaluation of the quality characteristics of the camera and video communication of the robot, its maneuverability when searching for the

optimal position for reading. Development of robot video vision programming skills.

Rationale:

Recognition of danger signs on barrels, boxes, cylinders and other containers. Obtaining the most complete information about the environment.

1.41. Anti-tank hedgehogs - an additional obstacle located in several cells. The processes are 9 cm long, 3 cm wide, and 1 cm thick. The actual height of the lying hedgehog is 140–150 mm, depending on the position. The height to the central part of the hedgehog is 70-80 mm.

Hedgehogs are scattered on the landfill in random order and impede free passage. Hedgehogs can be moved, pushed aside, carried from place to place.

Figure 44 Anti-tank hedgehogs

Tasks:

Don't get stuck on the anti-tank hedgehog.

Objectives:

This test is intended to demonstrate platform maneuverability, suspension capability and ground clearance.

Rationale:

Simulation of work on the territory of hostilities.Mines are cylinders resembling washers, recessed into the surface of the grass area.

The activation of the mine is accompanied by a light signal. Each minute can only be activated once per attempt. The diameter of the mines can range from 40 to 100 mm. The distance between mines is not less than 400 mm.
Demining:
The robot can deliberately defuse a mine, for example, with some foreign object on it. In this demining process, the robot cannot touch the mine with any of its parts. The robot gets points for clearing each mine.
Undermining on a mine:
For hitting a mine or activating a mine with any part of the robot, receives a penalty.

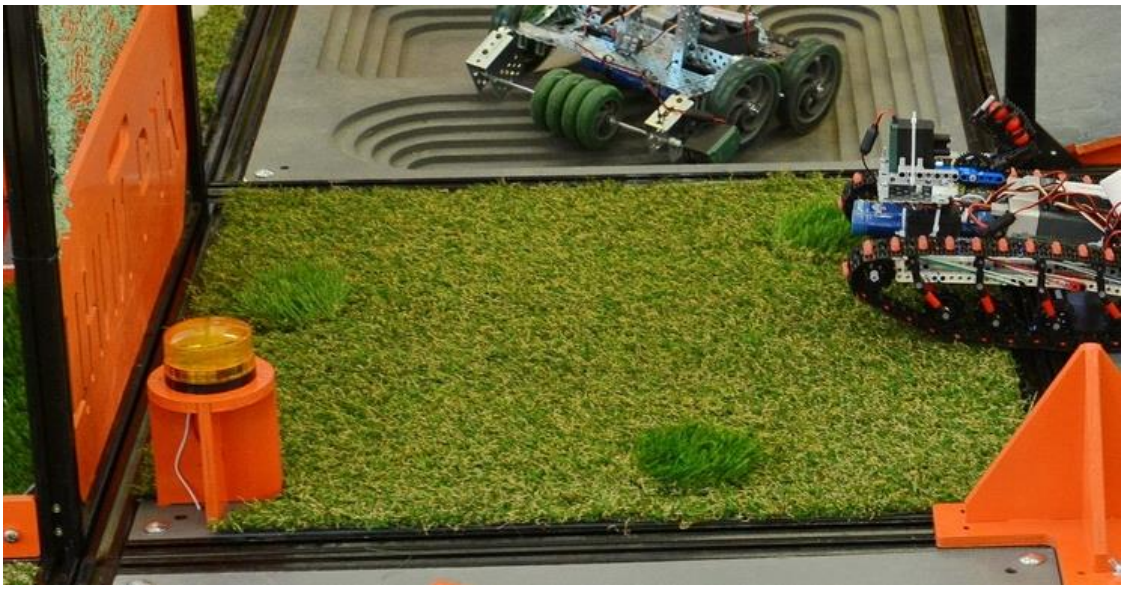


Figure 45 Mines

Tasks:
Drive through the cell and / or clear the field without being "blown up" by a mine.
Objectives:
This test is intended to demonstrate platform maneuverability and operator control skills, as well as the capabilities of navigation equipment.
Rationale:
Simulation of work in a minefield, conducting sapper works.

2. Floor 2

2.1. Hatch is a test located on the 2nd floor of the labyrinth, in a cell with a hatch instead of a floor, and also with a special beacon. When the beacon is removed, a timer is started. After the time (4 seconds) has elapsed, the hatch opens, and if the robot is still in the cell, it falls to the 1st floor of the labyrinth, onto the foam rubber floor.

Figure 46 Hatch

Tasks:
Capture the lighthouse and leave the cells within the allotted time. Further, the usual delivery of a special beacon to a special field (not necessarily for execution).
Objectives:
This test is intended to demonstrate the operator's control skills as well as the functionality of the arm, including accuracy and power.
Rationale:
Simulation of work in emergency conditions in buildings, on communications and technological equipment of industrial facilities.

The hypnodisk is a standard labyrinth cube with a 650 mm diameter rotating disc with variable speed, fixed in the top cover. Disc material - plywood 10 mm. The surface of the disc is covered with vinyl.

Figure 47 Hypnodisk

Tasks:
Overcome the challenge.
Objectives:
This test is intended to demonstrate operator control skills.
Rationale:

Simulation of meteorological emergencies - storms, hurricanes, tornadoes, squalls, vertical eddies.Trench - The test is a plywood platform with two 40 mm deep oblong rectangular trenches. The trench is 670 mm long and 140 mm wide. One trench is filled with tennis balls (65 mm in diameter), the other is empty.

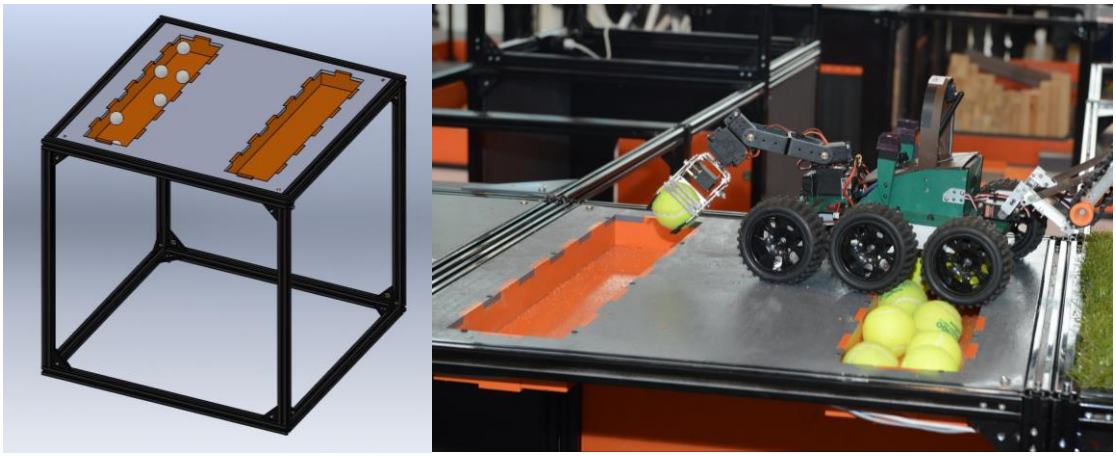


Figure 48 Trench

Tasks:

- Overcome the test
- Deliver the ball from one trench to another (optional). Points are awarded for each delivered ball.

Objectives:

Potential testing allows the robot's patency, as well as the functional characteristics of the manipulator, including its accuracy and power.

Rationale:

Simulation of the consequences of the release of radioactive waste (threat of release) of radioactive substances (collection of radioactive waste).Ribs - the test is a plywood platform with rectangular boxes alternating in a checkerboard pattern with overall dimensions of 355x120x40 mm (LxWxH).

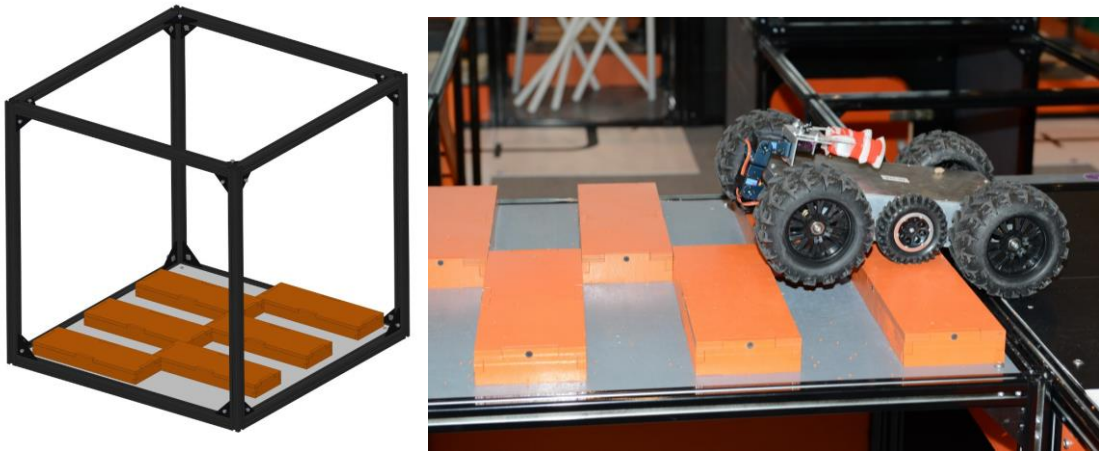


Figure 49 Ribs

Tasks:

Overcome the challenge.

Objectives:

This test is designed to demonstrate the robot's cross-country ability, engine power and suspension capabilities.

Rationale:

- Simulation of the consequences of a sudden collapse of buildings and structures for residential, social and cultural purposes, collapse of elements of transport communications.
- Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.

The suspension bridge is assembled from wooden planks 300x65x12 mm, fixed on slings 30 mm wide. The gap between the planks is 15-20 mm. The length of the bridge is variable, the width is 300mm.

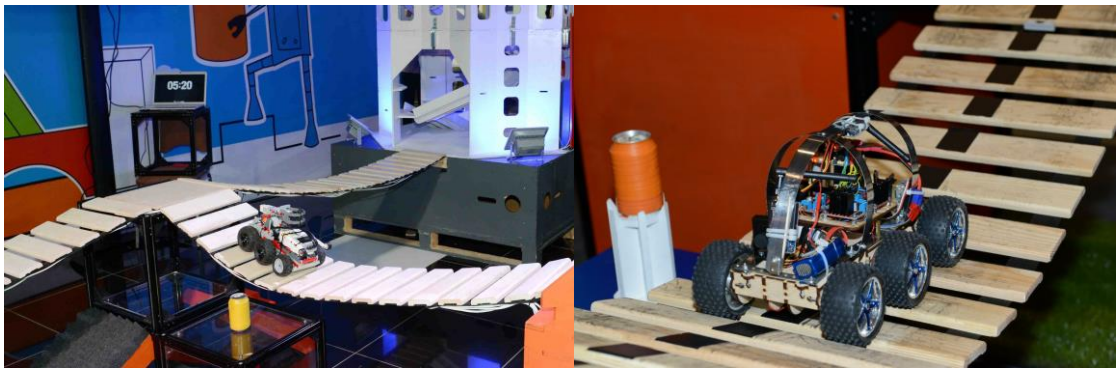


Figure 50 Suspension bridge

Tasks:

Overcome the challenge.

Objectives:

This test is intended to demonstrate the robot's patency on variable geometry surfaces and its suspension capabilities.

Rationale:

Simulation of work in emergency conditions in buildings, on communications and technological equipment of industrial facilities.

Descents / ascents

2.2. Inclined surface 20 ° - inclined, consists of 2 cells of the labyrinth, the entrance to which is a standard inclined 15 °. An inclined 20 ° leads to the second floor of the labyrinth.

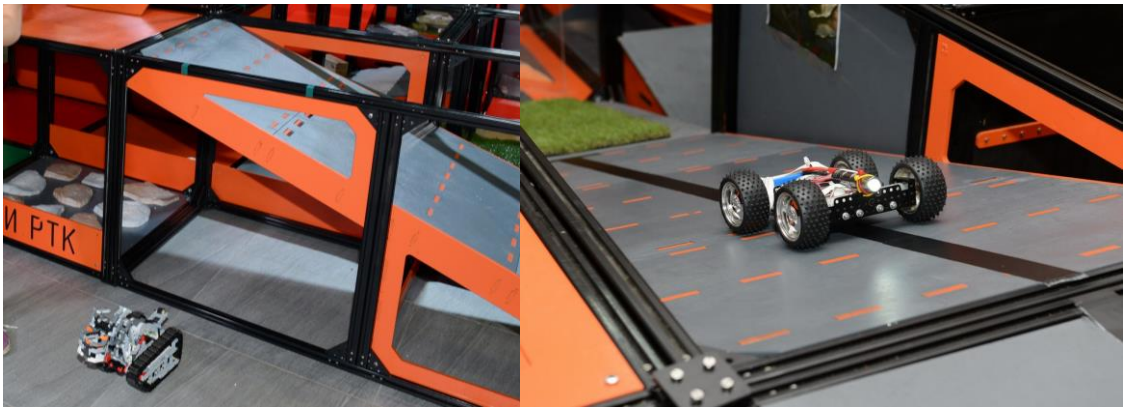


Figure 51 Inclined 20 °

Tasks:

Go up or down the slope.

Objectives:

Demonstration of the balance of gravity and the ability of the mobile robot to overcome inclined sections.

Rationale:

Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.Inclined 30 ° - Inclined leads to the second floor and occupies two standard polygon cubes. The test checks the power of the robot's motors and the wheel torque.

Figure 52 Inclined 30 °

Tasks:

Go up or down the slope.

Objectives:

Demonstration of the balance of gravity and the ability of the mobile robot to overcome inclined sections.

Rationale:

Simulation of the consequences of geophysical and cosmogenic emergencies - earthquakes, volcanic eruptions, asteroid fall.Mini ladder - the test is a standard polygon cube, inside which there a ladder is leading to the second floor of the polygon.

The staircase consists of eight steps 75mm high and 90mm long. A standard inclined (15 °) staircase leads to the staircase.

Figure 53 Mini staircase

Tasks:

Climb or descend the stairs in any way.

Objectives:

The ladder checks the robot's patency and the power of its motors.

Rationale:

Relocation within buildings to further protect fires, explosions or threats.Ladder with overall dimensions 1480x1220x620 mm, step height 150 mm, step width 340 mm.

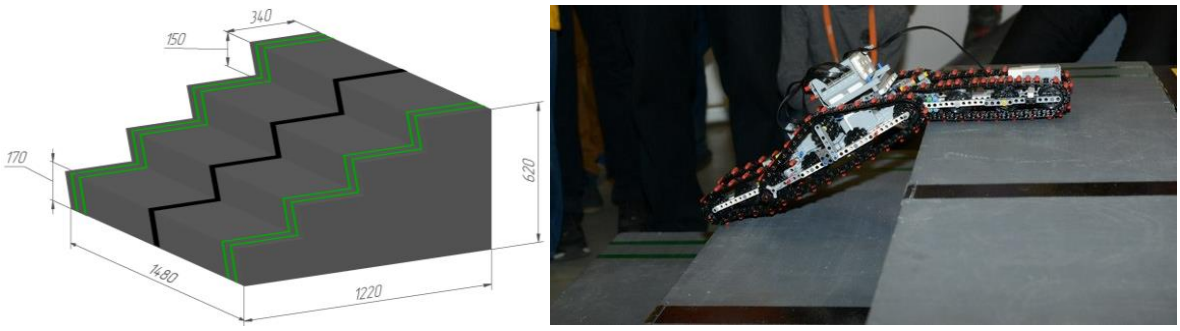


Figure 54 Staircase.

Tasks:

Go up or down the stairs in any way you want.

Objectives:

The ladder is designed to demonstrate and practice the movement of a mobile robot on surfaces with variable geometry.

Rationale:

Movement in buildings to further extinguish fires, explosions or explosion threats.

Autonomous sites

The line width in all areas is 50 mm.

2.3. Line movement

Tasks:

Overcome trials.

Objectives:

Demonstration of autonomous actions, accurate execution of tasks using sensors and background programs.

Rationale:

Simulation of work in conditions of difficult reception or in the absence of the possibility of radio exchange, as well as in the absence of the use of wired communication (emergency situations in buildings, on

communication and technological equipment of industrial facilities).Plots with a line (black on white) will provide 800x800 mm white fields with a black line, with intersections and turns. Beacons can be placed at intersections, which must be delivered by one of the intersections to another (any of the available ones).

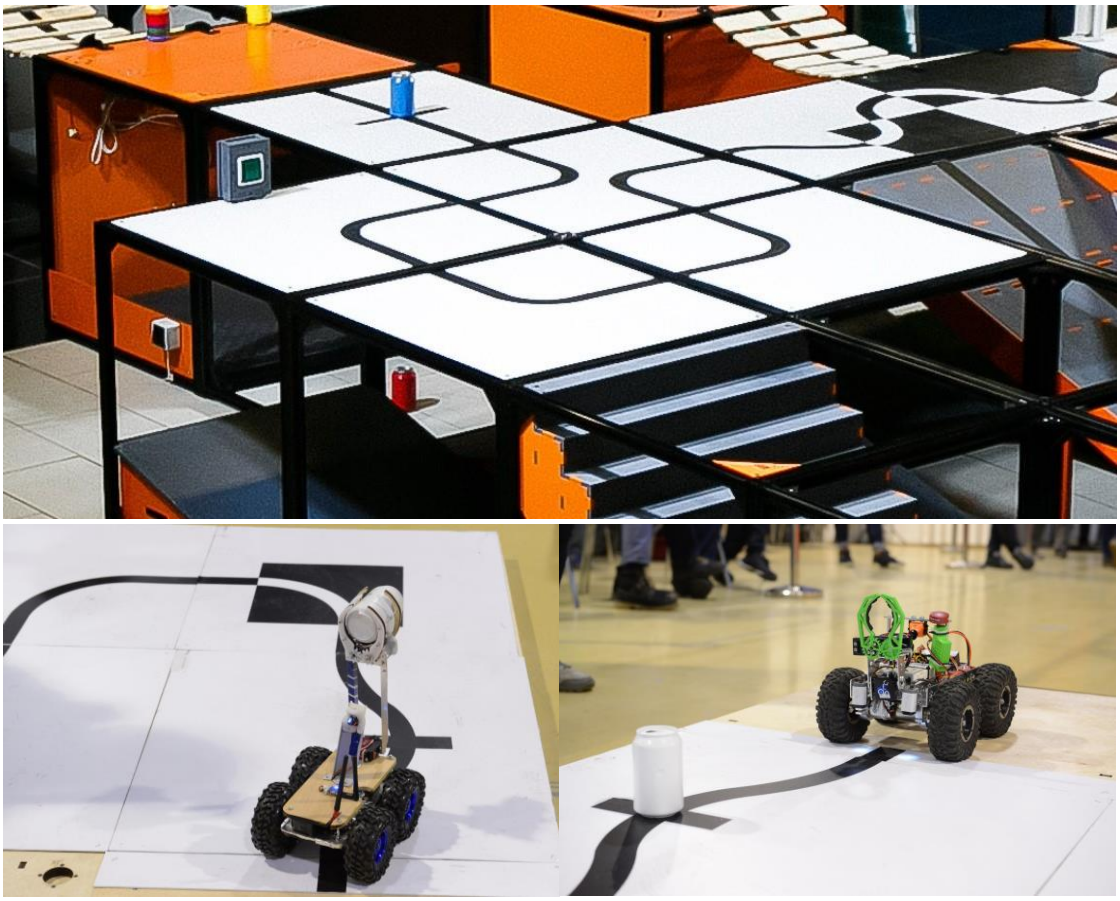


Figure 55 Areas with a line (black on white)

In front of the labyrinth, as a rule, there are two autonomous routes, each of the two starts has its own. Thus, the participants have the opportunity to perform autonomous movement along the line at the very beginning of the attempt to enter the maze. After passing its autonomous line (start), the team has the right to go through any exit (with an appointed start judge).

Figure 56 Autonomous sections at the start.

2.3.1. Areas with a line (black on gray) - black line on gray polygon details - inclined, gray fields, stairs.

2.3.2. Suspension bridges (dashed line) - black line on suspension bridge

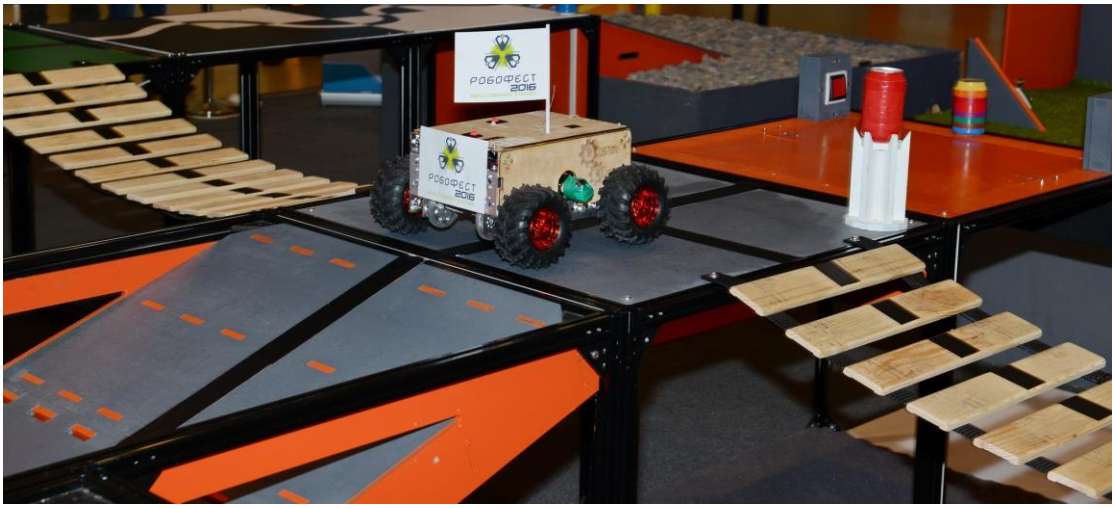


Figure 57 Areas with a line (black on gray). Suspension bridge

2.3.3. Areas with a line (black on color) provide yourself with colored fields for 800x800 mm beacons with a black line. Field colors: yellow and green.

Figure 58 Areas with a line (black on color)

3. Tasks for the manipulator

3.1. Collection of lighthouses - the lighthouse is a standard aluminum can with a volume of 0.33 liters. Banks have one of the following colors: red, blue, green, yellow.

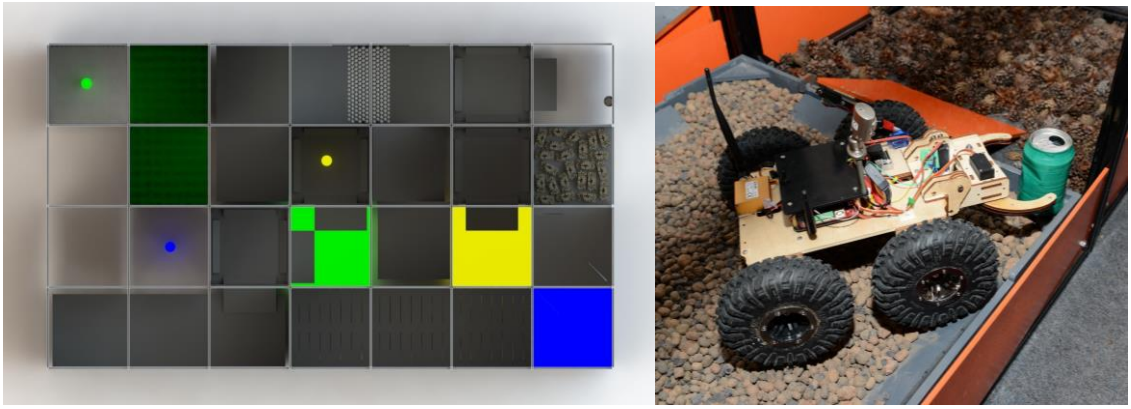


Figure 59 An example of the location of beacons and zones in the maze

Tasks:

Capturing and raising the lighthouse, and delivery in any way in the area corresponding to the color (plastic colored field) or on a special field (multi-colored field in a small cube). The assignment is not required to be completed.

Objectives:

The delivery of beacons improves the accuracy and maneuverability of the robot and the functionality of its manipulator.

Rationale:

Simulation of the consequences of the release of the release (threat of release) of chemical hazardous substances.Minitower - a pedestal, which is a miniature copy of the Tower, with dimensions of 160 mm high and 90 mm in diameter. A standard beacon is installed on it.

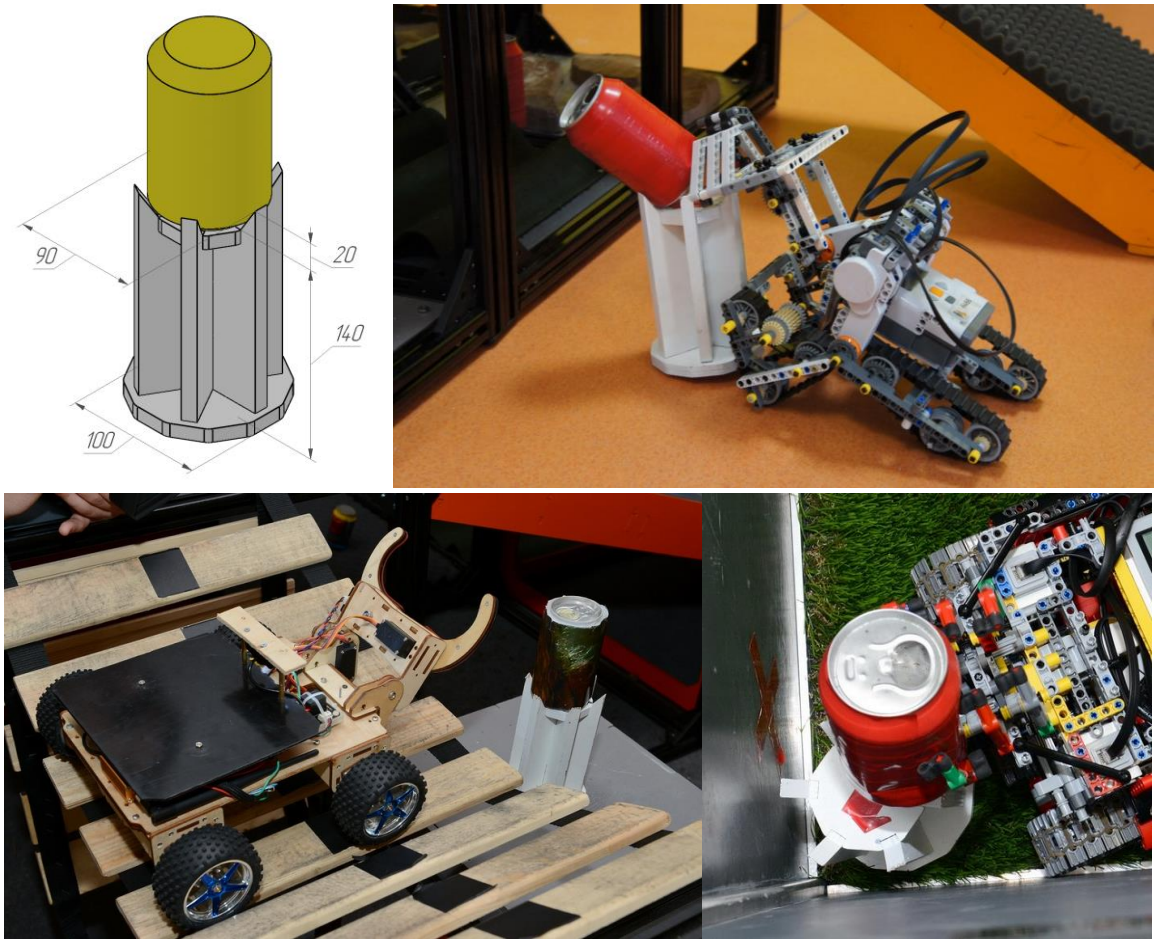


Figure 60 Turret with a lighthouse

Tasks:

Capturing and lifting the lighthouse from the mini-tower, and delivery by any means in the area corresponding to the color (plastic colored field). Delivery is optional.

Objectives:

The delivery of beacons improves the accuracy and maneuverability of the robot and the functionality of its manipulator.

Rationale:

Simulation of the consequences of the release of the release (threat of release) of chemical hazardous substances.Base

Colored boxes for beacon delivery can also be located at the bottom of the box with a frame. Delivery is counted when the beacon is dropped at the base, inside the box. Shipping cost is the same as for regular box.

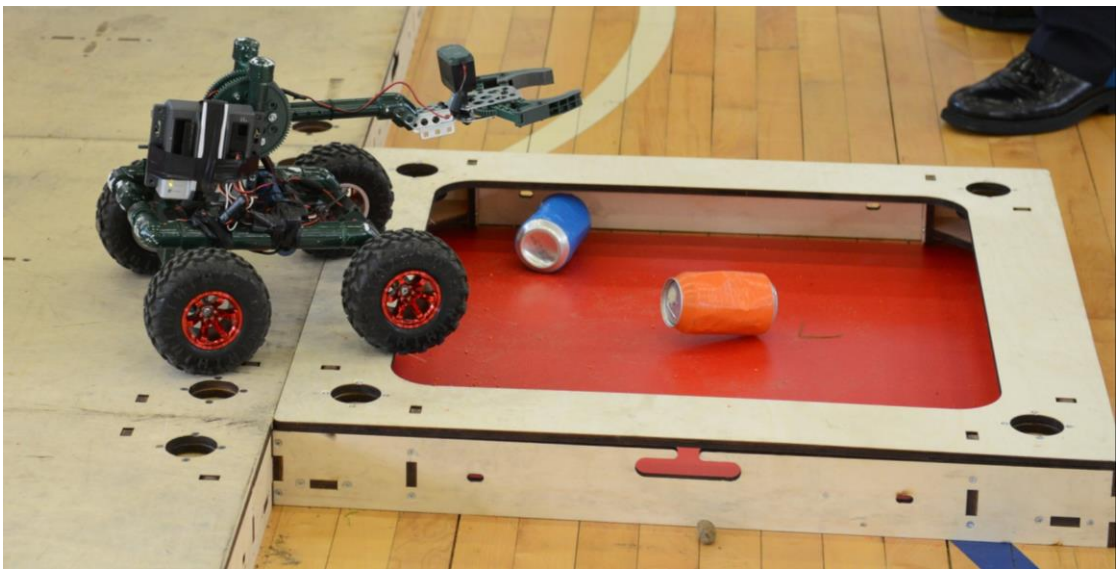


Figure 61 Delivery of the beacon to the base

3.2. Capture the Flag. Before the start, each robot is assigned a red or green color, depending on which entrance of the maze it starts from (indicated by arrows in the figure).

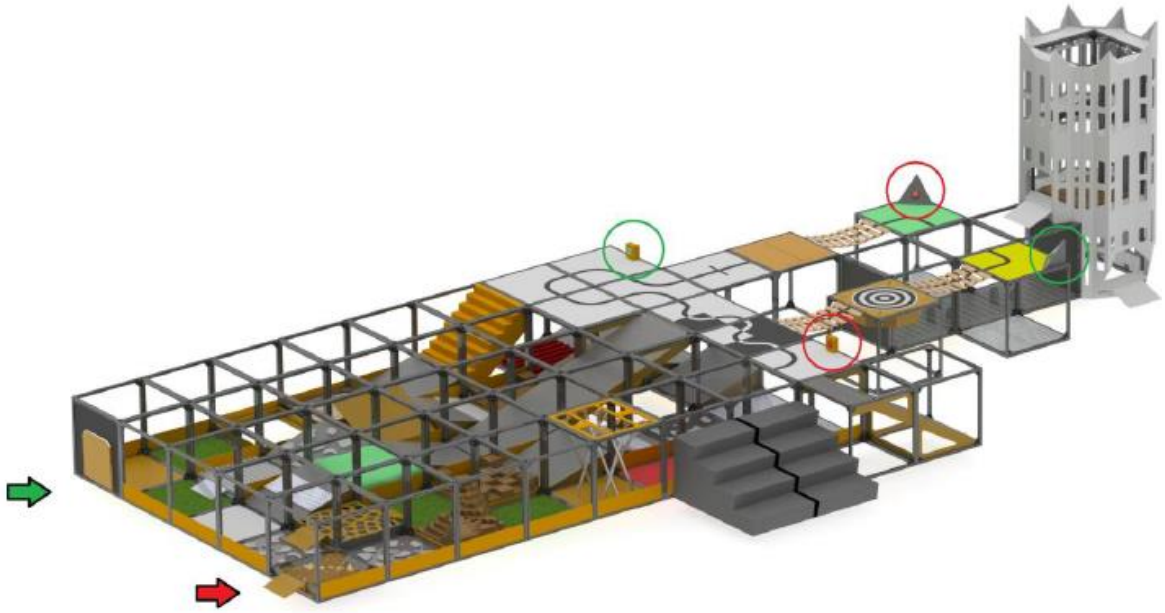


Figure 62 Capture the Flag

Tasks:

On the polygon there are buttons of two colors: red and green, when pressed, the Tower lights up red or green, respectively (circled in the figure with the corresponding color).

The robot, whose color the tower will burn at the end of the attempt, gets additional points. The rule works for both nominations, even if one robot is on the training ground at a time. You can press the button in any way.

Objectives:

Demonstration of the accuracy and maneuverability of the robot and the functionality of its manipulator.

Rationale:

Simulation of work in emergency situations in buildings, on communications and technological equipment of industrial facilities.

3.3. Pipes − is a structure of plastic pipes suspended from the cell wall. Each tube is terminated with a 40mm hexagonal cap. The length of the movable pipes is 60mm.

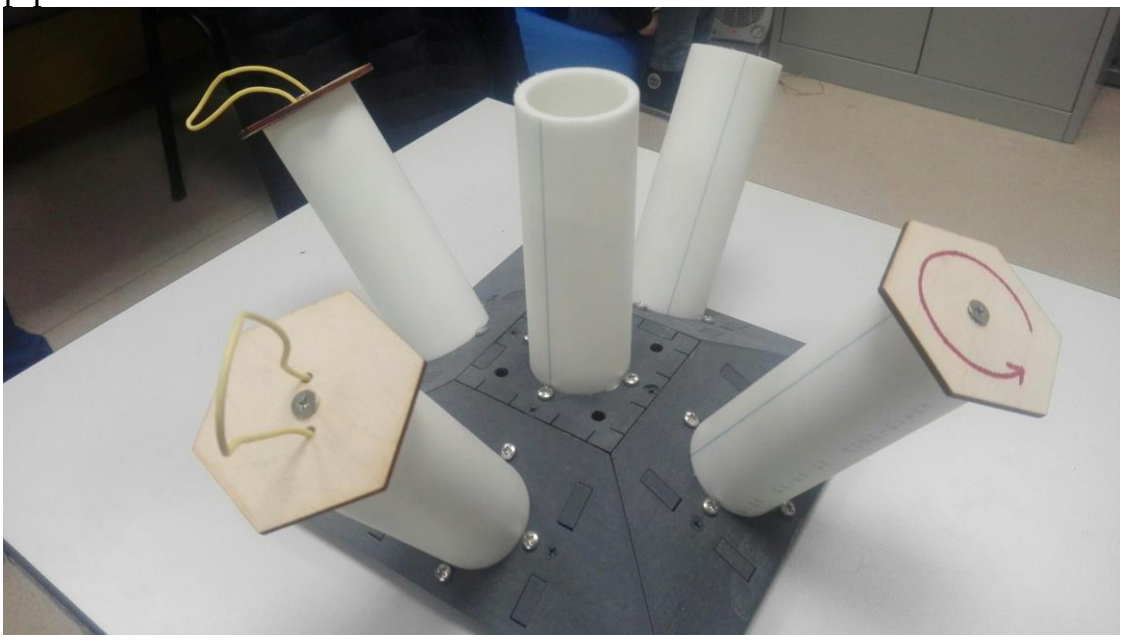


Figure 63 Pipes

Tasks:

A number of tasks can be completed with each pipe:

1. Remove: a tube with a smaller diameter is inserted into the pipe. The robot must grasp and remove the tube completely.
2. Turn: a tube with a smaller diameter is inserted into the pipe. The robot must rotate the tube around its axis, 360/180 degrees, without pulling it out of the main tube. One tube can be rotated **no more than one full turn (360 degrees).**
3. Investigate: a letter / number is written on the bottom of the pipe. The operator and judge must clearly see the symbol on the bottom of the pipe. The task is intended only for the "Extreme" nomination.

Objectives:

Demonstration of the accuracy and maneuverability of the robot and the functionality of its manipulator.

Rationale:

Simulation of work in emergency conditions in buildings, on communications and technological equipment of industrial facilities.

3.4. Debris - a test located in any part of the landfill, representing objects of different weights, sizes, shapes, textures. Materials: plastic, wood, rubber, foam rubber.

3.5. The dimensions of the wreckage range from 160 to 35 mm, weight up to 70 g.

Figure 64 Debris.

Tasks:

Collect items in a basket (basket height - 90mm). For the capture and delivery of each item, points are awarded separately.

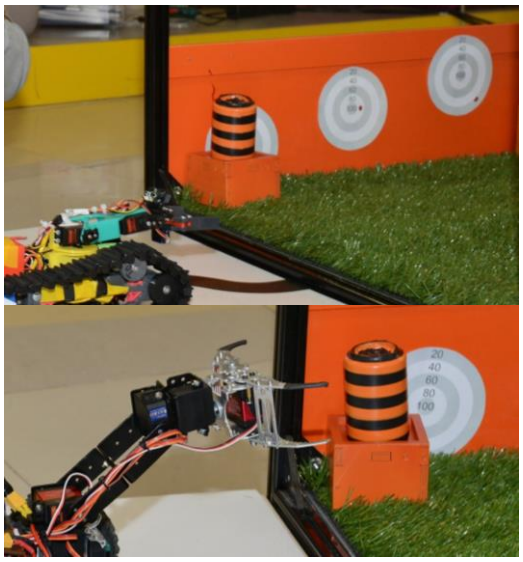
Objectives:

Demonstration of the accuracy and maneuverability of the robot and the functionality of its manipulator.

Rationale:

- Simulation of work in emergency conditions in buildings, communications and technological equipment of industrial facilities.
- Simulation of liquidation of the consequences of accidents with the release (threat of release) of chemical hazardous substances.

3.6. The target is concentric circles printed on paper and attached to the wall of the polygon. Three targets are fixed at different levels (for the convenience of robots of various designs). The target consists of 5 circles of different diameters. The diameter of the target itself is 15 cm.



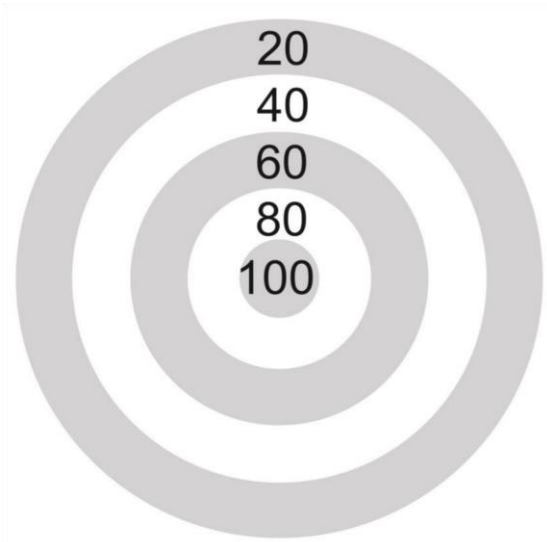


Figure 65 Target.

Tasks:

Capture a beacon with a marker fixed in it, and place a point as close as possible to the center of the target. The closer to the center the point is, the more points the participant will receive (from 20 to 100).

There is no limit to the number of attempts for this challenge. The best score for each target is scored. If the robot has drawn a line, then only the starting point is counted.

Objectives:

The test is designed to check the accuracy and degrees of freedom of the manipulator.

Rationale:

Simulation of work in emergency situations in buildings, on communications and technological equipment of industrial facilities.

3.7. Valves - a task for a manipulator of increased complexity. A structure of plumbing pipes with valves of various types and sizes is fixed on the wall: a lever (handle size - 90x15x5 mm, stroke - 90 °), medium butterfly (handle size - 50x15x5 mm, stroke - 70 °), small butterfly (handle size - 25x7x15 mm, stroke - 90 °), wedge gate valve (handle size - 50x15x5 mm, stroke - 3.5 full turns). The moment required to turn the valves:

- small butterfly and wedge gate valve - 0.3 Nm;
- lever - 0.5 Nm;
- medium butterfly - 1 Nm..

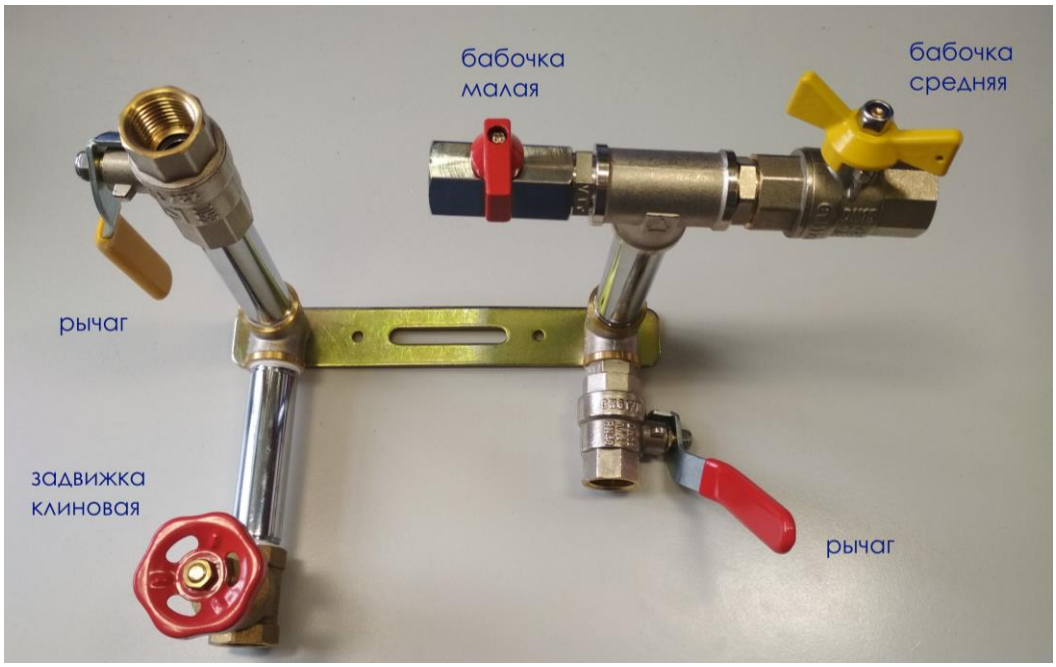


Figure 66 Valves.

Tasks:
Turn the valve until the markings on the valve overlap.
Objectives:
This test serves to demonstrate the characteristics of the manipulator: degrees of freedom, power of servomotors.
Rationale:
Overlapping of pipes in case of gas, water, steam leakage.

4. Tower

4.1. The tower with an elevator is a structure built on the basis of three standard heights of 800mm, equipped with buttons for typing combinations of symbols, and an elevator. Tower height 2400mm. The structure has ramps 400mm wide and 360mm high, with rounded or truncated corners. The number of entries varies depending on the landfill assembly and test location. The main entrance to the tower is on the second floor of the labyrinth.

4.2. On the upper tier of the tower there is an inclined tramp for the robot to "jump" from the tower.

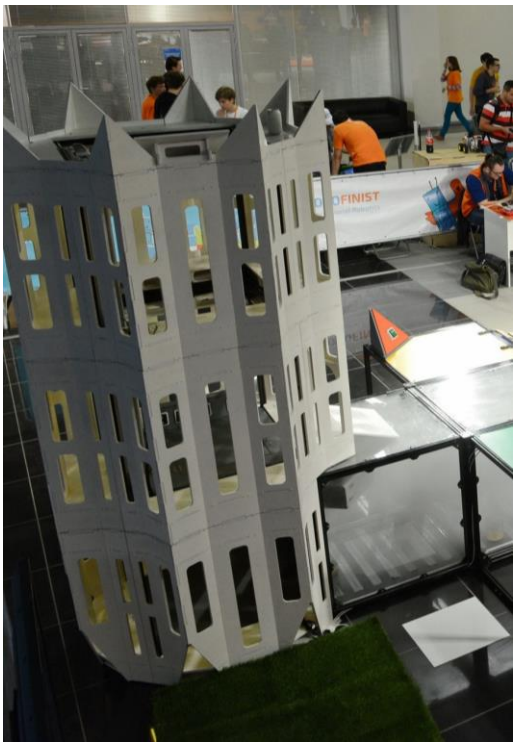


Figure 67 Tower

4.3. An elevator is a lifting structure set in motion when the robot enters a combination using buttons. Platform dimensions - 720x600 mm. Serves for lifting the robot to the upper tier of the tower, from where the robot can make a "leap of faith". The elevator cannot descend to the first floor of the labyrinth.

Figure 68 Elevator

Tasks:

Enter the elevator platform for a further set of combinations using buttons and ascent to the upper tier of the tower.

Objectives:

Demonstration of the accuracy and maneuverability of the robot.

Rationale:

Simulation of work in emergency conditions in buildings, on communications and technological equipment of industrial facilities.

4.4. Buttons in the tower - three household switches with latching and one without latching (switch without latching, marked with a yellow checkmark), fixed to the side wall of the elevator. Symbols are applied on three buttons (two geometric shapes on each). Thus, a symbol corresponds to each switch position. The fourth button (with a check mark) is a button to confirm the entered combination of characters.

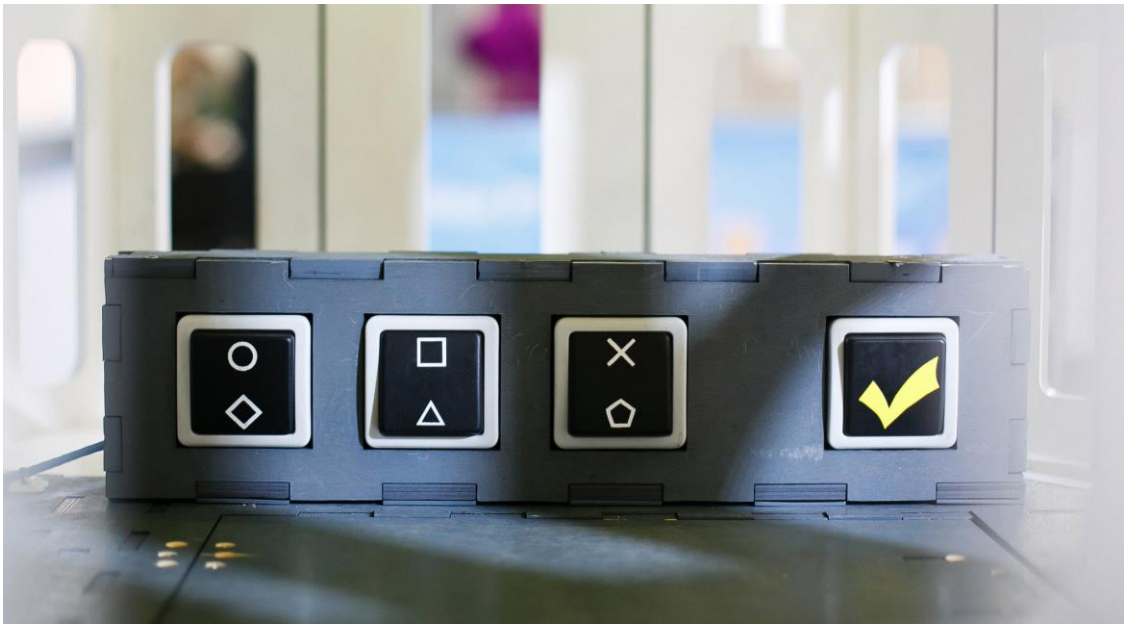


Figure 69 Elevator buttons

The symbols that make up the combination in this attempt are given to the participant in the form of tokens.

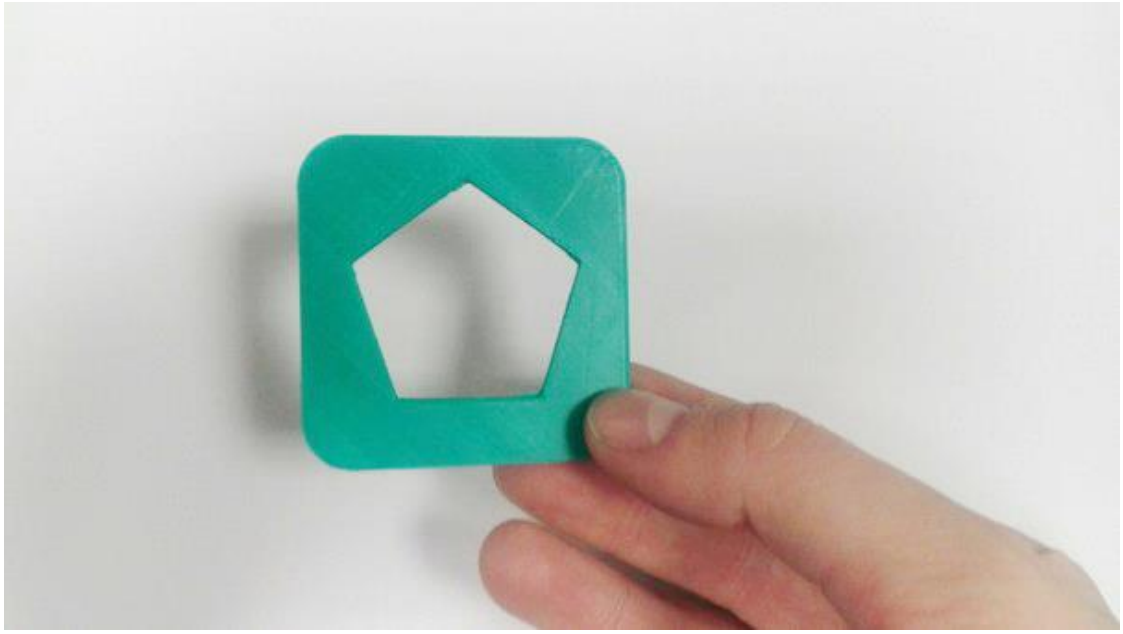


Figure 70 Token with a symbol

Tokens are awarded when passing tests, marked with special triangular plates at the top of the cube. There are seven or more such tests at the test site. The token can be obtained for any of the designated challenges. In total, the participant must receive three tokens in order to find out the whole combination.

Tokens are issued at the request of the participant during the attempt as the test progresses. If the participant has not requested the tokens himself, the judge will issue all three tokens at once (if three tests have been passed).

Figure 71 Test marked with a plate.

Tasks:

After receiving three tokens, a robot entering the elevator can enter a combination using the buttons, and then press the button with a checkmark, which will activate the elevator. Then the elevator reaches the third floor and stops for a few seconds. Further, two scenarios are possible:

1. The combination is typed correctly:

The elevator travels to the fourth floor, and the robot is on the top tier of the tower. The robot can either take a "leap of faith" or press the checkmark button again to lower the elevator down.

2. The combination is typed incorrectly:

The elevator platform falls under the robot, and the robot falls from the height of the 3rd floor of the labyrinth (1800 mm) into the basement of the tower, onto the foam rubber floor. You can leave the basement and find yourself on the level of the first floor of the labyrinth.

Note: if the participant did not earn tokens or did not earn all three, he nevertheless has the right to enter a combination at random, at his own peril and risk.

Objectives:

The test is intended to demonstrate the capabilities of the robot's actions in a confined space and the properties of the robot arm: accuracy, effort.

Rationale:

Simulation of work in emergency conditions in buildings, on communications and technological equipment of industrial facilities.

4.5. The leap of faith is made from a springboard on the upper tier of the tower (height above the floor - 2500mm). The springboard is an inclined 350 mm wide, set at an angle of 30 °. On the floor in the jump zone, there is artificial grass with a foam backing.

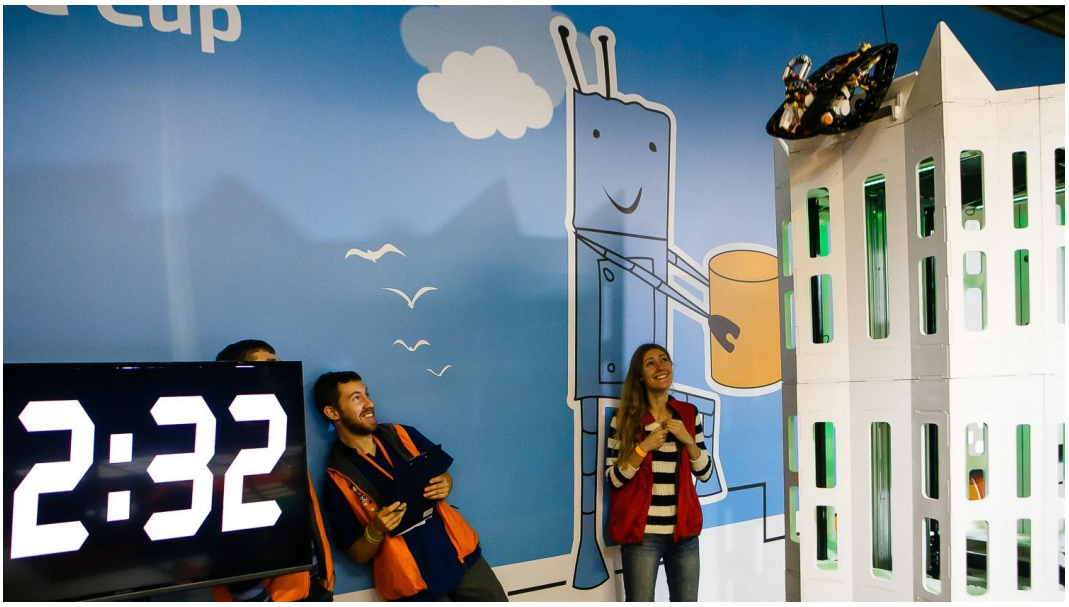


Figure 72 Leap of Faith

7 Stand configuration

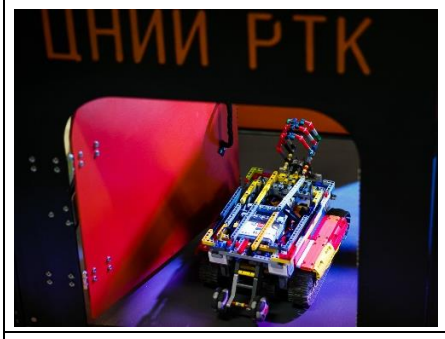
The configuration of the training ground and the location of obstacles become known to the participants on the day of the competition, directly in training. The final list of possible obstacles and the points awarded for them become known to the participants at least one week before the start of the competition.

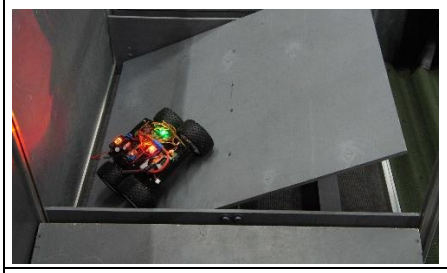
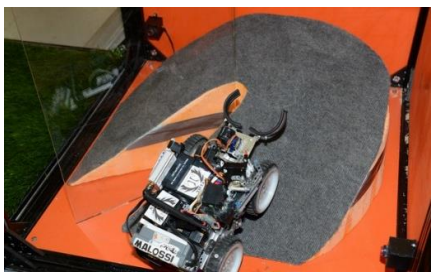
Some individual details, obstacles and their location may be changed and added immediately before the start of the competition due to unforeseen circumstances.

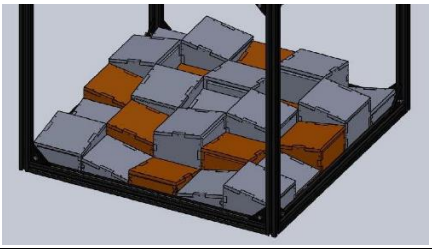
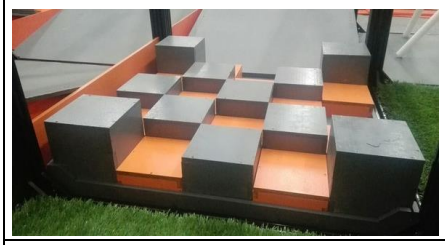
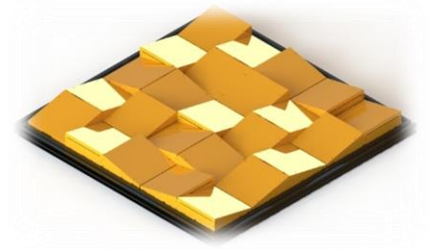
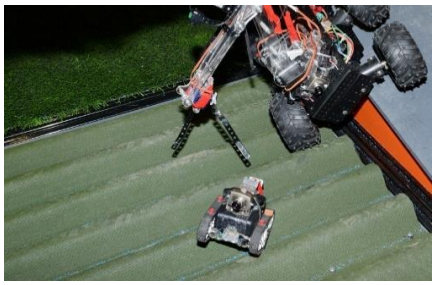
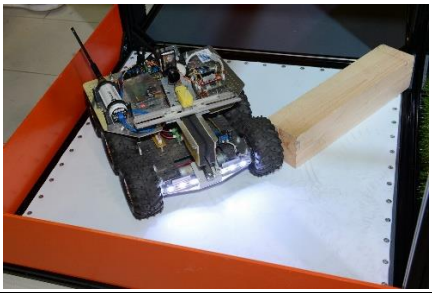
Appendix 2. RTC CUP: Brest, RTC CUP: Final. Scoring System

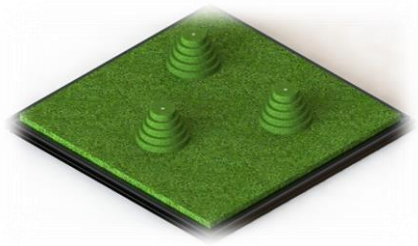
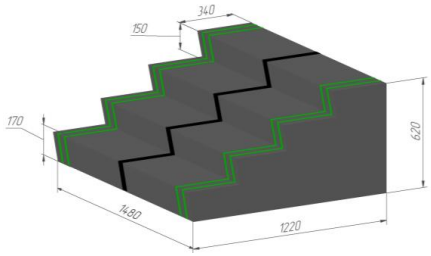
The scoring system and the conditions of task's execution. Autonomous action.

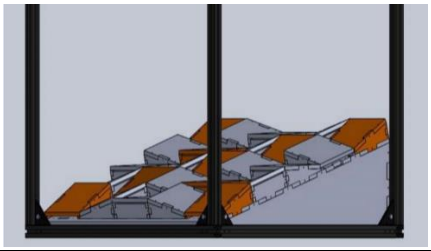
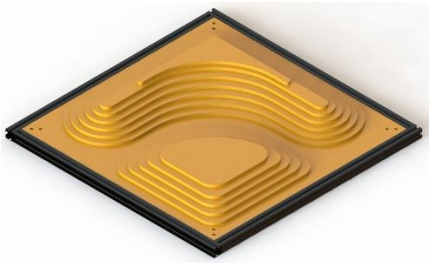
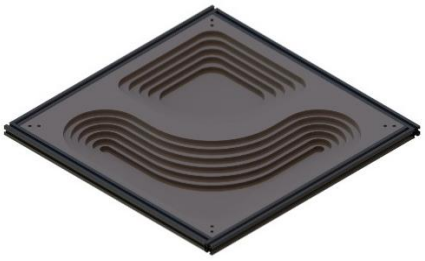
Table 1 – «Methods of execution and scoring points number"

Picture	Section	Execution	Points	Elevator	Location
	Ball pool	Passing through	80	Yes	1 floor
	Logs	Passing through	100	Yes	1 floor
	Wood Pile	Passing through	170	Yes	1 floor
	Door: inward	Opening door inward and travel through	60		1 floor
	Door: outward	Opening door outward to the latch and travel through	15		1 floor
	Narrow slope 15 ° grass / stones	Passing through	45		1 floor

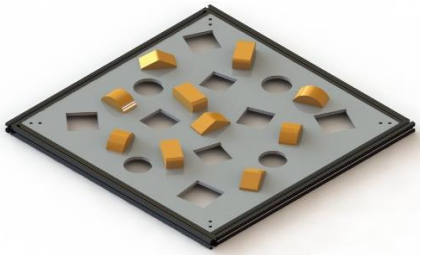
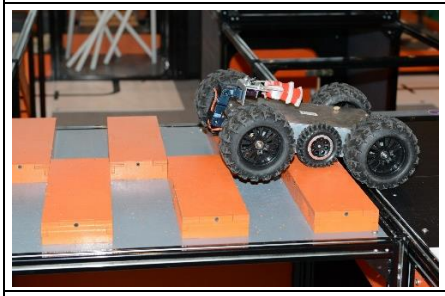
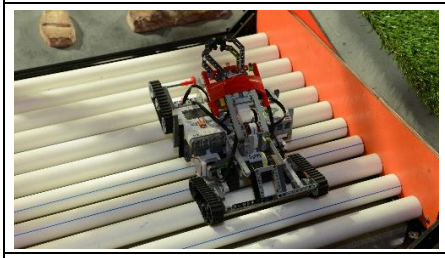
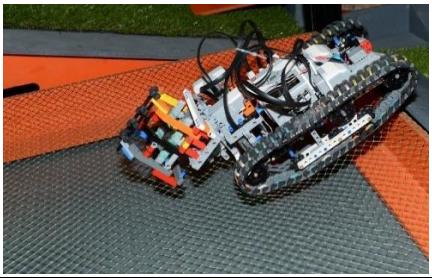
Picture	Section	Execution	Points	Elevator	Location
	Blockage	Passing through	50		1 floor
	Stone slope 15 °	Passing through	45		1 floor
	Stones	Passing through	30		1 floor
	Seesaw	Passing through along the axis. Allowed ride / check back on the swing	60	Yes	1 floor
	Expanded clay	Passing through	30		1 floor
	Hoof	Passing through	45		1 floor

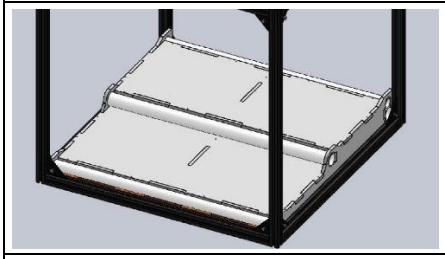
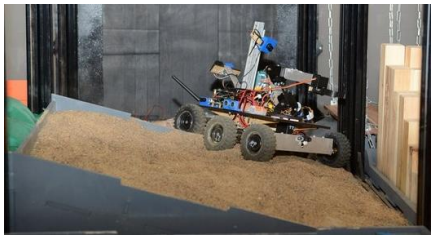
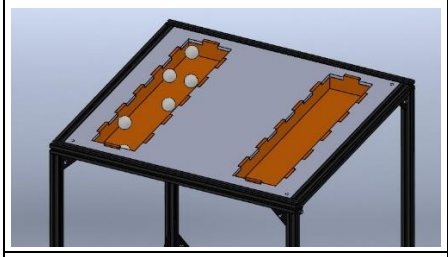
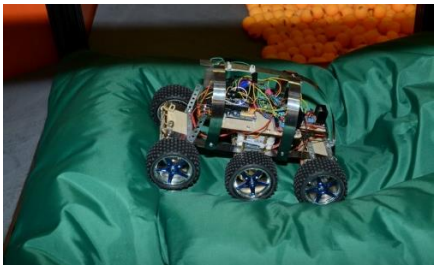
Picture	Section	Execution	Points	Elevator	Location
	Align ramps	Passing through	35		1 floor
	Align ramps-2	Passing through	90	Yes	1 floor
	Straight ramps	Passing through	80	Yes	1 floor
	Agro ramps	Passing through	40		1 floor
	Roof	Passing through	35		1 floor
	Ice	Passing through	25		1 floor
	Ice slope 15 °	Passing through	40		1 floor

Picture	Section	Execution	Points	Elevator	Location
	Forest	Passing through	50		1 floor
	Mini staircase: climb	Climb up in any way	300	Yes	1 floor
	Mini staircase: descend	Climb down in any way	70	Yes	1 floor
	Staircase: climb	Climb up in any way	500	Yes	1 floor
	Staircase: descent	Climb down in any way	90	Yes	1 floor
	Staircase: autonomus climb	Autonomous line following	1000	Yes	1 floor
	Staircase: autonomus descent	Autonomous line following	270	Yes	1 floor
	Mines deactivation	Mine deactivation (the robot should not touch the mines)	50	Yes	1 floor
	Mines safe pass	Passing through (without deactivation)	35		1 floor
	Inclined surface 15 °	Climb / descent	15		1 floor

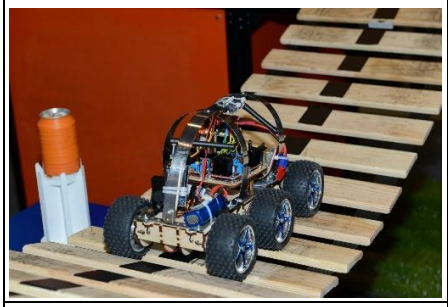
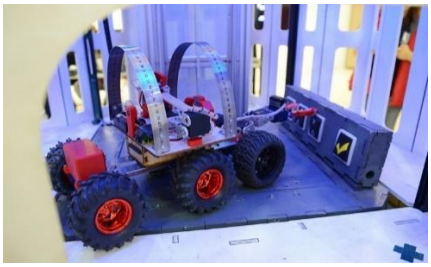
Picture	Section	Execution	Points	Elevator	Location
	Inclined surface 20 ° (2 cells)	Climb / descent	30		1 floor
	Inclined surface 20 ° (2 cells): autonomous	Autonomous line following	90		1 floor
	Inclined surface 30 ° (2 cells)	Climb	50	Yes	1 floor
	Inclined surface 30 ° (2 cells)	Descent	30		1 floor
	Inclined surface 30 ° (2 cells): autonomous	Autonomous line following	90		1 floor
	Inclined surface with ramps	Passing through	50		1 floor
	Canyon	Passing through	60		1 floor
	Pit	Passing through	60		1 floor
	Sand	Passing through	40		1 floor
	Foam under the Hatch	Passing through	15		1 floor

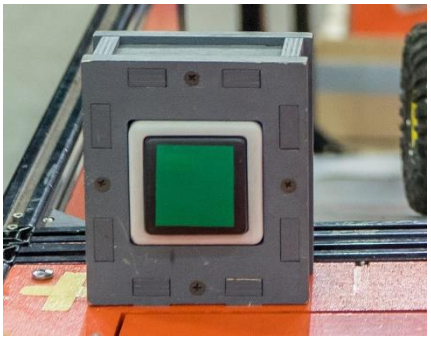
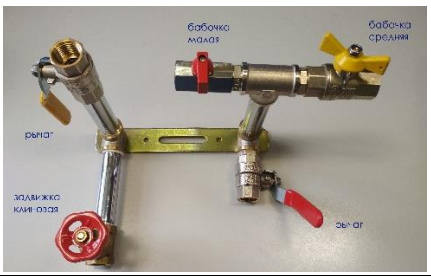
Picture	Section	Execution	Points	Elevator	Location
	Coup - A coup driven - The coup autonomous	If the robot is overturned or turned upside down, it returns to its original state (stands on the" wheels"). - - If the robot performs a flip using a manipulator or similar devices, the team receives a credit in the category of manipulators. - If the robot performs a flip only using the main running gear (for example, as a result of hitting a wall), the team does not receive a credit in the manipulator category. This option also applies to the case when the robot turns over spontaneously, without control, only due to its design (for example, a rounded body). A coup is counted if the robot performs the task automatically, without operator intervention and without using remote control, and with the help of sensors that allow you to determine the robot's position in space, the team receives a credit in the category of autonomy.	120 240	Yes	
	Sand	Overcoming	40		1 floor
	Foam under the Hatch	Overcoming	15		1 floor

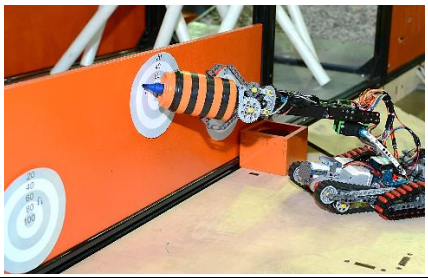
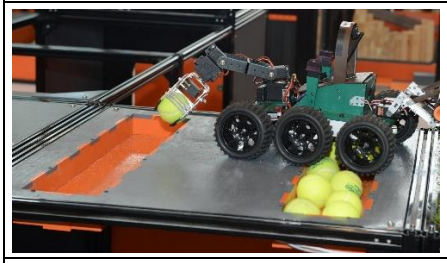
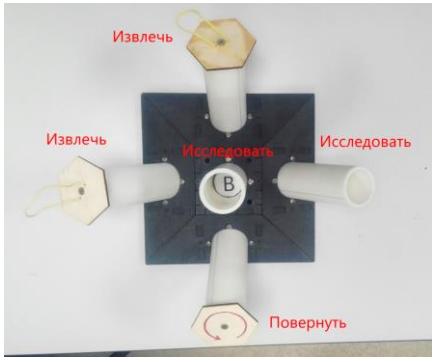
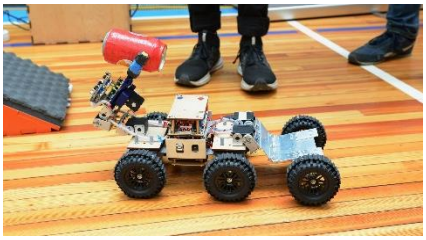
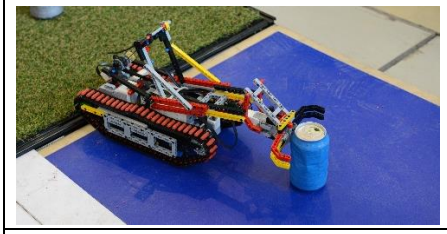
Picture	Section	Execution	Points	Elevator	Location
	Wires	A box with a bunch of "wires". Passing through	55		
	Ragged road	Passing through	80		
	Rails	Passing through	60	Yes	1 floor
	Broken floor	Passing through	35		1 floor
	Ribs	Passing through	45		1 floor
	Rolling pipes	Passing through	30		1 floor
	Net	Passing through	35		1 floor

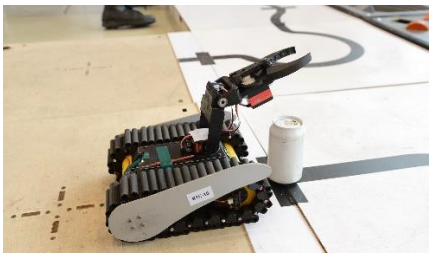
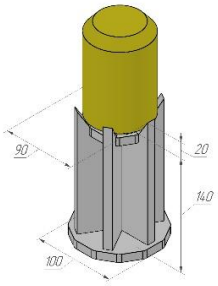
Picture	Section	Execution	Points	Elevator	Location
	Steps with pipes	Passing through	55		1 floor
	Sand Slope	Passing through	75	Yes	1 floor
	Gravel Slope	Passing through	65		1 floor
	Grass	Passing through	10		1 floor
	Grass slope 15 °	Passing through	25		1 floor
	Trench	Passing through	40		1 floor
	Swamp	Passing through	60	Yes	1 floor
	Fog (1 cell)	Passing through	35	Yes (For 3 cells)	1 floor

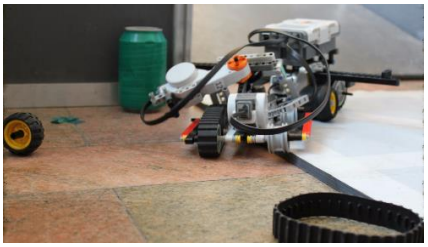
Picture	Section	Execution	Points	Elevator	Location
	Fog: light button	Press a button to light up the cell	30		1 floor
	Spikes	Passing through	65	Yes	1 floor
	Pine cones	Passing through	30		1 floor
	Hypno disk	Passing through	80	Yes	2 floor
	Flag capture: the button	Press a button to light up the Tower	30		2 floor
	Flag capture	The Tower glows your color at the end of the attempt	150		2 floor
	Line: black on grey	Autonomous traffic on the line	50		2 floor

Picture	Section	Execution	Points	Elevator	Location
	Hatch	Activating the Hatch to open	40	Yes	2 floor
	Suspension bridge	Passing through	40		2 floor
	Suspension bridge: punctured line	Autonomous line following	120	Yes	2 floor
	Tile with line: black on white	Autonomous line following	50	Yes (for 2 tiles)	2 floor
	Plot with a line: black on colored	Autonomous traffic on the line	70		2 floor
	Elevator: combination lock	Enter combination using buttons and activate the Elevator	50		Tower
	Elevator: lift up to the 4th floor of the Tower	Lifting up to the top floor of the Tower on the platform of the Elevator	300		Tower
	Elevator: descent from the Tower	Descend down from the top floor of the Tower to the 2nd by pressing the button	40		Tower
	Basement (1st floor of the Tower)	Escape from the basement of the Tower	30		Tower

Picture	Section	Execution	Points	Elevator	Location
	Trust Fall: free fall	Jump from the top floor of the Tower	150		Tower
	Trust Fall: controlled descent	Descent from the Tower in any way (except elevator or free fall)	300		Tower
	Trust Fall: robot keep on moving	The robot keep on moving without repair	300		Tower
	QR codes	Reading code: By robot (decryption of the code appearing on the operator screen). Pass as an autonomic action By smartphone from the operator screen image	60 35		
	Danger sign	Reading the sign by the robot with the output of the decryption on the screen and marking the location of the sign (frame) Counts as an offline action	100		
Manipulation tasks:					
	Any button	Pressing any button with manipulator (robotic arm)	30-50		
	Valves	Rotate 90 ° Lever Wheel Stub S Stub M	 100 110 120 120	Yes	1 floor

Picture	Section	Execution	Points	Elevator	Location
	Target	Touch round target with the marker. Best result score. Marker is embedded in the can.	100 80 60 40 20		1 floor
	Shatters: capture	Capture one shatter	40	Yes, 3 pc	
	Shatters: delivery	Deliver one shatter	30	Yes, 3 pc	
	Trench: ball capture	capture a ball from a trench	50	Yes	
	Trench: ball delivery	put a ball into second trench	30		
	Pipes: extract	Extract one pipe	50		1 floor
	Pipes: explore	Exploring a pipe operator should be able to see clearly the image inside	50		1 floor
	Pipes: rotate	Rotate the pipe on 180 ° Rotate the pipe on 360 °	90 120	Yes, 1 pc (for 360°)	1 floor
	Pipes: touch	Touch the center of a round target with the marker.	20-100		
	Standard beacon (can): capture	Capture, lift (no less than 2 cm high) and hold (no less than 1 sec long) a can	30		
	Standard beacon (can): delivery	Deliver a can to a field with according color	60		
	Standard beacon (can):	Capture a can autonomously	90	Yes	

Picture	Section	Execution	Points	Elevator	Location
	autonomous capture				
	Auto beacon (can): autonomous capture	Capture a can, standing on the line, autonomously	60	Yes	
	Auto beacon (can): autonomous delivery	Deliver a can on next line “crossroad” autonomously	80	Yes	
	Special beacon (can): capture	Capture, lift (no less than 2 cm high) and hold (no less than 1 sec long) a can	50	Yes	
	Special beacon (can): delivery	Deliver a can to a field with according color	80	Yes	
	Special beacon (can): autonomous capture	Capture a can autonomously	150	Yes	
	Heavy beacon (can): capture	Capture, lift (no less than 2 cm high) and hold (no less than 1 sec long) a can	60	Yes	
 	Heavy beacon (can): delivery	Deliver a can to a field with according color	90	Yes	
	Heavy beacon (can): autonomous capture	Capture a can autonomously	120	Yes	
	Mini-tower beacon (can): capture	Capture, lift (no less than 2 cm high) and hold (no less than 1 sec	70	Yes	

Picture	Section	Execution	Points	Elevator	Location
		long) a can from the “mini-tower stand			
	Mini-tower beacon (can): autonomous capture	Capture a can autonomously from the “mini-tower stand	140	Yes	
Penalties:					
	Penalty: attempt reschedule	For rescheduling the attempt until later time. Can be done only once	-50		
	Penalty: repair time-out	For touching the robot for repair or relocation (if it stuck). Can be done only once	-70		
	Penalty: lost robot parts	For losing parts during the attempt. Condition: a part should come loose fully from the robot. Can be done multiple times	-30		
	Penalty: touch to enter automode	For touching the robot (pressing the button) to enter automode. Can be done twice	-10		
	Penalty: the robot explodes on a landmine	The robot explodes on a landmine (light flashes). Can be done thrice	-50		1 floor