ROBOSOFT GRAND CHALLENGE

ROBOSOFT GRAND CHALLENGE 2016

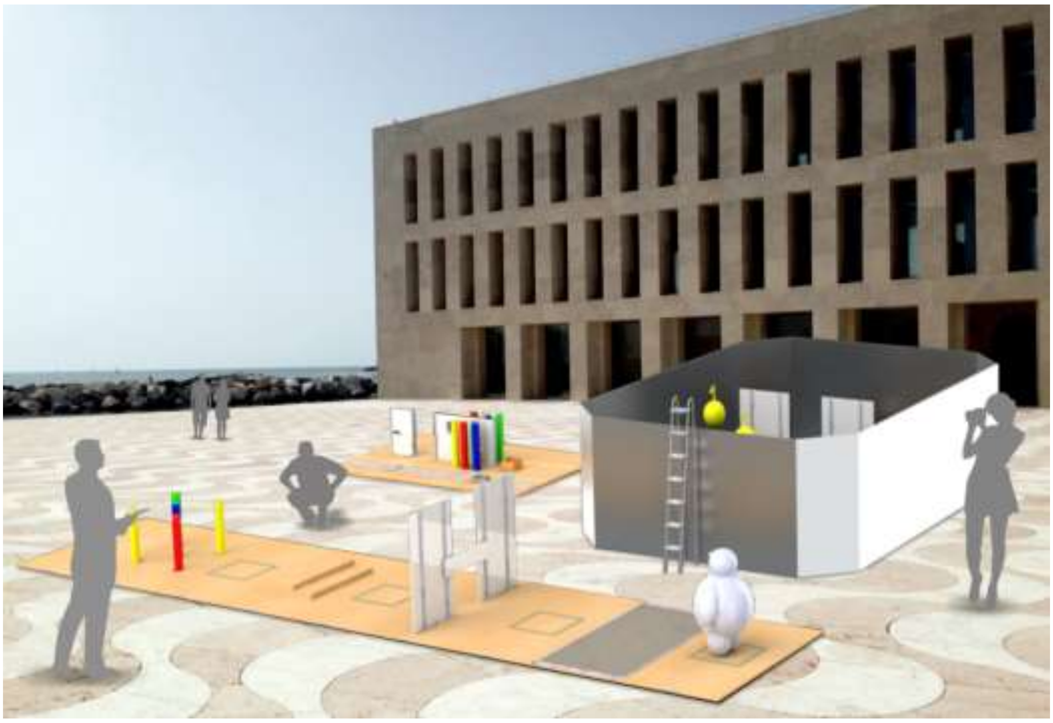
SCENARIOS AND RULES[1]

DATE:

29-30 APRIL 2016

VENUE:

RESEARCH CENTRE ON SEA TECHNOLOGIES AND MARINE ROBOTICS, LIVORNO, ITALY



VERSION DATE: 04/03/2016

[1] The organizers can change, refine, and develop the following rules till the first day of the challenge. Please visit regularly the http://www.robosoftca.eu/information/events/robosoft-grand-challenge for the latest version.

CONTENT

CHALLENGE OVERVIEW

The RoboSoft Grand Challenge is a competition which invites teams to test the design and control of their robots in challenging scenarios. It is intended for soft robots and the tasks were designed to tackle specific features of soft robots, like resilience, body compliance, delicate contact and deformability.

The overall aim of the challenge is twofold: on one hand, it challenges state of the art soft robots; on the other hand it pushes the performance of soft robots beyond the state of the art to increase their impact value.

Teams may comprise any combination of students, faculty, industrial partners, private partners or government institutions without maximum number of people per team. Students may be both graduates and/or undergraduates. One member of the team must be designed as Team Leader (TL): only the TL can speak for the team during the competition.

The RoboSoft Grand Challenge is made of scenarios which approximate real-world robot applications. Specific parts of the scenarios require peculiar robot features which were never requested in other competitions so far, such as body shrinking, delicate contact and compliant manipulation (see Figure 1). These scenarios cover some domains of soft robotics where research is particularly lively. Three different scenarios are proposed, and particularly they are:

1. Terrestrial race

2. Manipulation

3. Underwater race

FIGURE 1: THE OVERALL AIM OF THE ROBOSOFT GRAND CHALLENGE IS TO HIGHLIGHT SOFT ROBOTS FEATURES (SUCH AS RESILIENCE, COMPLIANCE AND DELICATE CONTACT) AS WELL AS TRADITIONAL ROBOTS CHARACTERISTICS (FOR EXAMPLE STRENGTH AND DEXTERITY).

Each scenario is split down into tasks: points are awarded by completing partially or totally the tasks, and a scenario will be considered cleared if the robot completes all tasks. The robot that will earn the maximum overall amount of points will be considered the winner of the RoboSoft Grand Challenge, but a robot should score in at least two scenarios to be eligible for the Grand Challenge victory. Each team participates with one robot, but multiple subscriptions are allowed, that is a team can subscribe twice with two different robots. As an example, Team A subscribes Robot-a and Robot-b to the challenge. With Robot-a, Team A clears scenarios 1 and 3, for a total score of 30 points. With Robot-b, Team A clears scenarios 1 and 2, for a total score of 25 points. To the purpose of the Grand Challenge scoreboard, the maximum amount of points is considered and not the sum of the single contributions, thus in the scoreboard Team A is awarded of 30 points.

It is worth to mention that points are awarded independently for each task, thus a robot can complete tasks 1-3 from scenario 1, and tasks 3-4 from scenario 3. Four robots will be awarded: the first in ranking of each scenario and the Grand Challenge winner. If the Grand Challenge winner is also the winner of a specific scenario, the second robot in the ranking will be elected as winner for that scenario. Practically, a robot should be awarded once.

OFFICIAL INFORMATION

The official information and interpretation about rules will be available on the RoboSoft Grand Challenge website http://www.robosoftca.eu/information/events/robosoft-grand-challenge).

Rules (including this documents) and scenarios are subject to change. Please check regularly the RoboSoft Grand Challenge website for last updates.

In case of any question, participants are invited to read carefully this document, and for further specifications to contact the organizers at **robosoftgrandchallenge@gmail.com**.

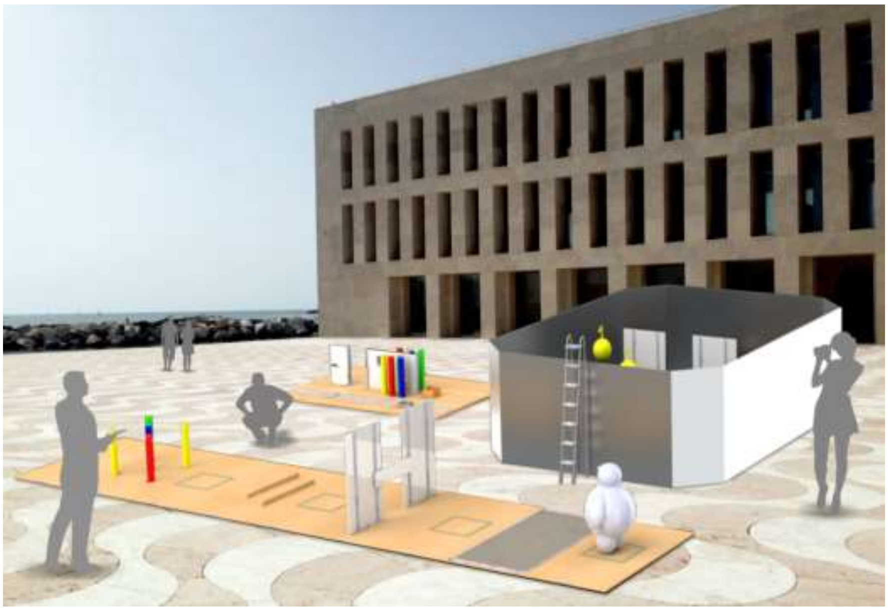


FIGURE 2: DEPICTION OF THE FIELD AREA: ACCESS INSIDE CHALLENGE SCENARIOS IS GRANTED ONLY TO THE OPERATORS AND THE JUDGES. PUBLIC SHOULD BE LOCATED OUTSIDE.

AWARD

A total amount of 5000 € is the RoboSoft award that will be distributed among the winner teams: one winner team for each scenario and one winner team for the Grand Challenge.

For each winner team, the amount of money prize will be transferred to its institution that will provide to distribute the money to the members of the team itself.

FINANCIAL SUPPORT TO THE PARTICIPATING TEAMS

RoboSoft offers the opportunity to teams' members participating in the Grand Challenge to get financial support for travelling, accommodation and meals accordingly to the following rules.

Reimbursement will be allowed for travel costs, accommodation and meals, for a maximum of 2 members for each team attending the RoboSoft Grand Challenge upon presentation of original receipts, tickets and boarding cards.

Reimbursement can cover the costs only for the period of the RoboSoft Grand Challenge, i.e. from the day before the event (April 28, 2016) to the last day of the event (May 1, 2016).

Travelling: the cost of the flights can be reimbursed for low-cost or economy class air tickets for a maximum of 800 € for flights from non-EU countries and a maximum of 500 € for flights from European countries and associated countries. If you plan to come by car, we will reimburse you a fixed amount per km (please provide evidence of the distance with a trip itinerary printed from Google maps of similar) and highway tolls. Taxi reimbursement is allowed only on the days of arrival and departure from/to airport/railway station to/from the location of the event.

Accommodation: The Hotel for the participants is the Boston Hotel (http://www.bostonh.it/hotel-livorno/?lang=en).

Reservation should be made directly by the participants by writing an email to: info@bostonh.it

Reservation should be made in double room. If a single room is required, please send an email to inform and to justify, In case the hotel is completely booked, please inform us and consider that the reimbursement is allowed for a maximum of 3 nights, with a maximum of 100 €/person/night.

Meals will be included in the event organization. In case they are not, we will reimburse you the cost of the meals, for a maximum of 50 €/day and a maximum of 30 €/meal.

Note: All costs are calculated by considering the mean rate of good quality hotels and restaurants in Livorno in the period of the event and the cost of flights to reach the location in the same period. Before the event, participants will be informed about a number of hotels and restaurants near the venue and in agreement with the organizers for staying and eating.

VENUE AND SCHEDULE

The RSGC will take place at the Research Centre on Sea Technologies and Marine Robotics, Livorno, Italy on **April 29th-30th 2016.**

FIGURE 3: THE RESEARCH CENTRE ON SEA TECHNOLOGIES AND MARINE ROBOTICS

A preliminary schedule of the challenge is shown in the following table:

Day	Date	Events
1	Friday, 29 April	• Teams arrival and registration • Setup and testing • Preliminary (ground) tests on the challenge fields
2	Saturday, 30 April	• Morning: RoboSoft Challenge 2016 • Afternoon: Awards ceremony

A set-up location will be provided to each team. It will be equipped with the following minimum facilities:

- Table/work surface
- 220 V power plugs
- Internet connection

Additional equipment will be evaluated by the committee upon request, however teams should be as autonomous as possible, bringing all the material they need. Further information regarding schedule and facilities will be provided a few months before the challenge.

The main phases of the application procedure are reported below, along with the most important dates.

2015				**2016**			
Jun. 30th	**Sept. 30th**	**Oct. 1st**	**Dec. 31th**	**Feb. 1st**	**Mar. 15th**	**Apr. 29th**	**Apr. 30th**
Rules are published	*Intent form submission closes*	*Submission of the pre-selection material opens*	*Submission of pre-selection material closes*	*Admitted teams are notified*	*Team registration closes*	*RoboSoft Challenge Starts*	*RoboSoft Challenge Ends*
Intent		**Pre-selection**		**Registration**		**Challenge**	
Robot development							

APPLICATION PROCEDURE

INTENT EXPRESSIONS

The committee will first ask the teams to submit an *intent form* to express their potential interest in participating to the RoboSoft Grand Challenge. Submitting an intent form is necessary in order to participate to the Challenge. However, it is not binding in any way, i.e. you can submit an intent form and then decide not to proceed with later stages of the challenge.

Each team will be asked to provide basic information regarding the team (e.g. team composition, affiliation of the members, previous experience with robot competitions, etc.) and the robot (e.g. current development stage, etc.).

Important: *the intent form refers to one robot. In case your institution is planning to participate with more than one robot, an intent form should be sent for each of them.*

The intent form can be found at http://www.robosoftca.eu/information/events/robosoft-grand-challenge.

The deadline for the submission of the intent form is **September 30th**.

The intent form shall be sent to: robosoftgrandchallenge@gmail.com

PRE-SELECTION PHASE

To ensure high quality of the participants, a pre-selection phase will take place in which a technical committee will evaluate the eligibility of each robot. During this phase each team has the possibility to submit some videos demonstrating the skills of the robot at the current stage of development. Each video will be accompanied by a short technical document, summarizing the current stage of development as well as the main improvements over time.

Each submission will be composed of one video (max 5 minutes long) and one technical document (format can be found at the challenge website http://www.robosoftca.eu/information/events/robosoft-grand-challenge). It is suggested to improve the latter over time, and link it in each video description (i.e. avoid multiple copies of the technical document). Each team is allowed to submit at most **four times** during the pre-selection phase.

Optionally, feedbacks may be provided by the committee to the teams, with the aim of motivating rejection. However, teams can resubmit by taking into account committee feedback in order to raise the chance of the robot of becoming eligible.

Important: *in order to be eligible, at least one submission of the pre-selection material must be performed before the deadline of the pre-selection phase, that is set to December 31th.*

Although no more feedbacks will be provided by the committee after December 31th, teams can continue the development of the robot until the Challenge starts.

The acceptance notification will be on February 1st.

HOW TO SUBMIT THE PRE-SELECTION MATERIAL

The submission of the pre-selection material is performed via the YouTube web platform. Each submission will consist in uploading a YouTube video, shared privately with the committee. When uploading a video, please make sure to select the *"Private"* option, then enter the following email address in the *"Share to"* field: **robosoftgrandchallenge@gmail.com**. This ensures that the material is shared privately.

Important: *each video must contain a link to the accompanying technical document. You can upload that document wherever you like, and insert the link in the video description.*

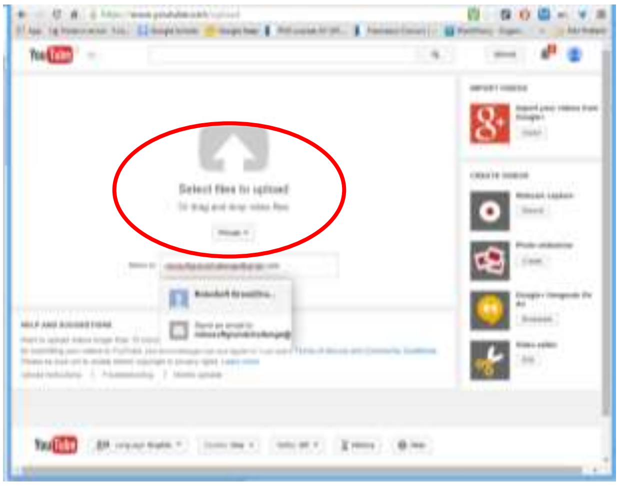


FIGURE 4: PRIVATELY SHARING A VIDEO VIA YOUTUBE

SKILLS TO BE SHOWN IN THE VIDEO / EVALUATION CRITERIA

Skills to be shown are directly related to scenarios and tasks: teams should demonstrate minimum capabilities of their robots allowing them to be competitive during the challenge. A complete list is presented here, grouped by scenario:

1. Terrestrial race
    a. Locomotion on flat ground
    b. Passive/active body shrinking
2. Manipulation
    a. Picking of objects (by grasping, curling around, etc…)
    b. Manipulator dextrous positioning (demonstrate several poses of the robot/manipulator)
3. Underwater race
    a. Swimming
    b. Passive/active body shrinking

The evaluation criteria will be on a do-it base, thus a simple video demonstrating the ability to perform one of the skills listed above grants the eligibility. Although performing well in all the tasks and scenarios of the challenge is the most desirable result, you can expect that many of the opposing teams will decide/be able to tackle only a subset of the tasks/scenarios. We thus encourage teams to submit their pre-selection material even if their robots are able to show only one or few of the aforementioned skills.

TEAMS' REGISTRATION

The registration form is available at:
http://www.robosoftca.eu/soft-robotics-week-registration
For any further question, you can contact Laura Margheri at laura.margheri@sssup.it

RESTRICTIONS

Although the Grand Challenge is designed to encourage creativity and imagination, some restrictions are required due to logistics.

Robot maximum dimensions: 60x60x60 cm.

Robot maximum weight: 20 kg.

Power supply: 220V electric power supply will be provided, while other power sources will be evaluated on request. Please check the plug standard currently in use in Italy.

Robots can be either tethered or untethered, they can be teleoperated or they can have autonomous behaviour. No additional points will be awarded depending on autonomy or tethering.

All underwater vehicles must be battery powered, with a DC voltage not exceeding 60V. Upon acceptance, teams will be required to submit a technical description of their robot to evaluate potential safety issues. Any vehicle consider unsafe by the judges will be disqualified.

Keep in mind that the organizer are not responsible to damage to persons or objects. Teams are responsible for all the safety requests their robot demands, or for the safety of their actions during the competition.

THE GRAND CHALLENGE SCENARIOS

The Grand Challenge is composed by 3 subchallenges (or scenarios) described in detail in the next sections. The time to complete each scenario starts when teams are ready and the TL communicates to the judge the beginning of the trial. When a team is summoned to a certain scenario, it has 5 minutes to deploy the robot and the supporting material. If the deployment takes longer, the judge starts the countdown of the scenario time (thus the extra time needed for the deployment is deducted by the time allowed to complete the task). An example of the competition field is presented here.

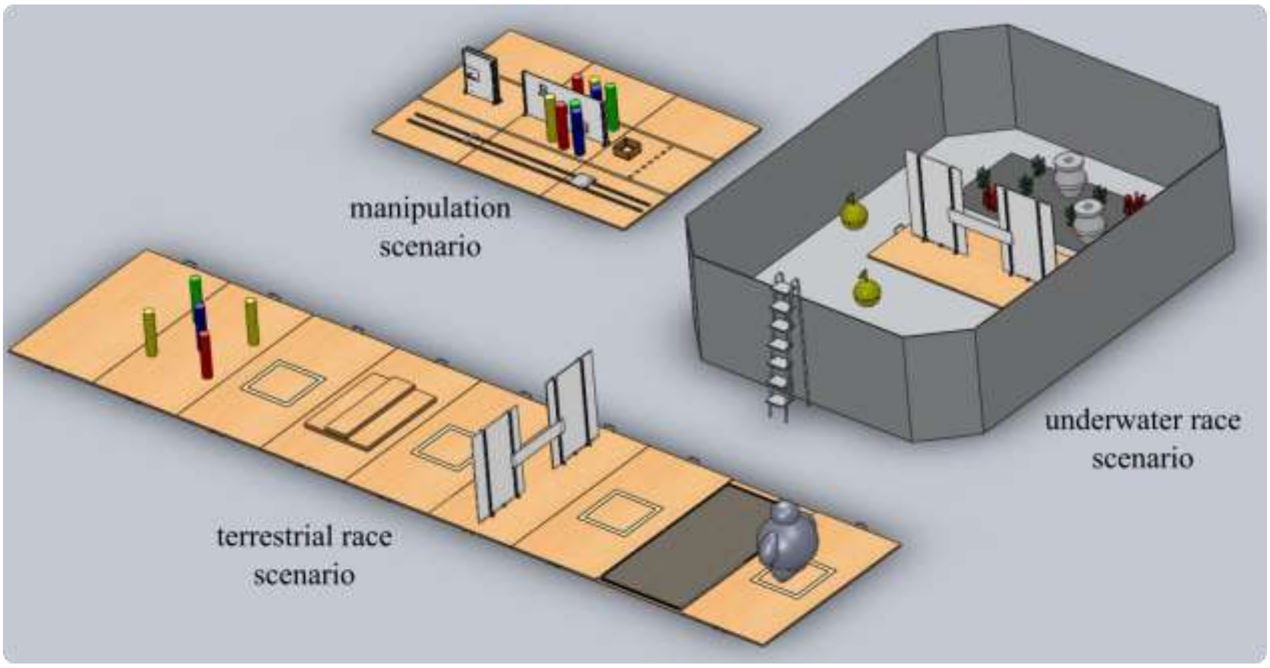


FIGURE 5: OVERALL GROUND: IT IS COMPOSED BY THE TERRESTRIAL RACE, MANIPULATION AND UNDERWATER RACE. FINAL ARRANGEMENT OF THE SCENARIOS COULD VARY.

Teams will engage in scenarios without a fixed predetermined order, that is the terrestrial race is not strictly followed by manipulation, but each team can be summoned to the corresponding scenario area to optimize the challenging time. During a trial, teams will receive a maximum time slot upon which they must complete the scenario or part of it (that is completing a certain number of tasks). Depending on the scenario, they will receive additional points by taking into account specific multipliers (i.e. it is possible to tune the difficulty of some tasks to obtain additional points, as explained in the scenario details). Only two operators (one operator should be the TL himself) can participate in the trial and are allowed to operate inside the competition field, together with at least one judge who will supervise the execution of the trials.

The execution of a task can be stopped at each moment by the judges, or the TL can request to stop the trial. This can happen for safety issues or because the operators consider the robot stuck. After the TL request, the judges allow the operators to physically interact with the robot and to replace it in order to perform another attempt. Specific checkpoints are defined inside scenarios to provide the starting positions for the various trials. A maximum number of three attempts for each task can be performed, after which the task is considered not completed and the robot should be moved by the operators to the next checkpoint. A fraction of the total points can be assigned to the robot in case the task is partially completed (see scenario details in the section The Grand challenge scenarios).

The number of trials required to complete a task also affects the scoring, i.e. the maximum score can be earned by completing the task with the first attempt, then the score decreases at each subsequent attempt The complete scoring is reported in section Scoring.

After the clearance of each scenario, teams are allowed to move all the necessary equipment to the next scenario, and to check robot functionalities. Each team is allowed to quickly fix, reprogram and test the robot before the next scenario. However, major hardware modifications are not allowed (i.e. adding or removing parts/tools). Violating this rule will result in disqualification.

TERRESTRIAL RACE

GENERALITY:

The robot is deployed in an environment which comprises several obstacles to be negotiated to reach, as fast as possible, the end of the scenario. This scenario simulates an urban area (comprising an unstable building) which is not accessible by humans: the robot should be deployed far from the building, than it should go inside it passing through a small aperture and negotiate the environment to reach the end of the scenario.

DESCRIPTION:

The robot starts from an obstacles-free tile and should move forward toward the first obstacle tile (task 1) which is a sand box representing the ground outside a collapsed building. The second obstacle tile (task 2) represents an aperture of the building which the robot should enter. The third obstacle tile (task 3) represents a stair which the robot should negotiate moving upward and downward. The last obstacle tile (task 4) represents a congested, unstable environment which could collapse if the robot exerts too much force onto the structural elements. All obstacle tiles are separated by obstracles-free tiles with the function of checkpoints.

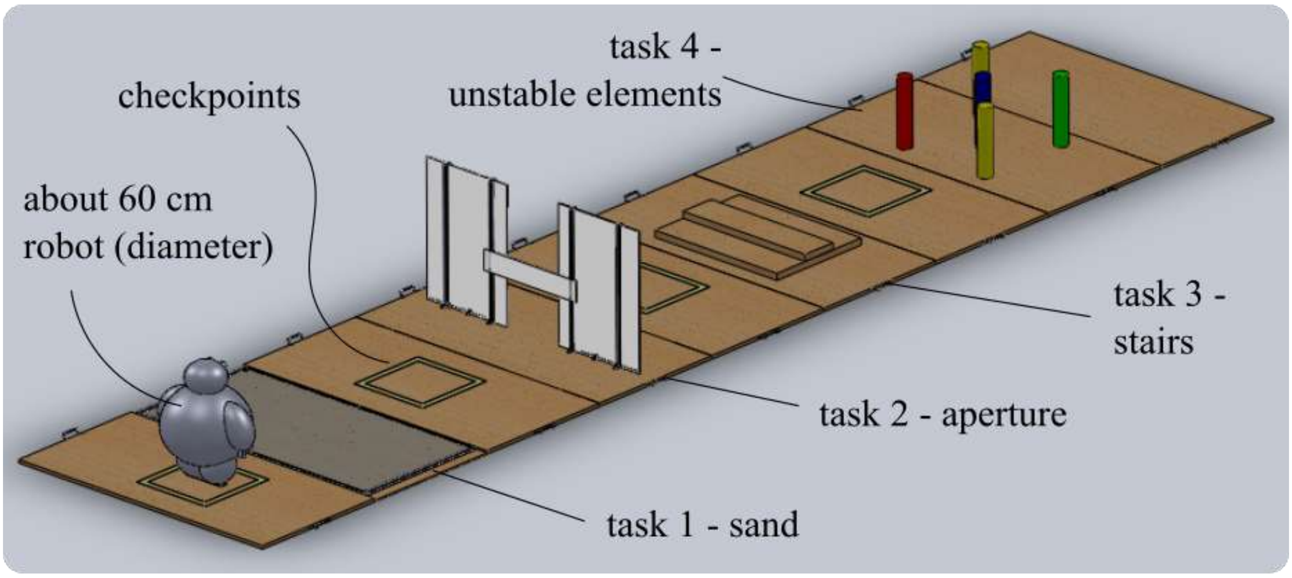


FIGURE 6: THE TERRESTRIAL RACE STARTS WITH A SAND TILE, FOLLOWED BY AN APERTURE, THEN A TILE WITH THREE STEPS AND FINISHES WITH A TILE WITH UNSTABLE ELEMENTS.

SCENARIO DETAILS (BROKEN DOWN INTO TASKS):

- Task 1: The sand box is approximately 2 meter long and 1 meter wide. It has about 1,5cm of sand with not predefined granularity. From the starting tile to the sand tile, the ground could be uneven, thus a small step of few centimeters could be required to enter into and exit from the tile. Task is considered partially solved if the robot move at least to the middle of the tile.

- Task 2: The wall tile is made of three rigid PVC elements which can be moved to reduce the aperture dimensions, see Figure 7. Approximately, the aperture will be a square of side s, where s should be decided by teams as follow.

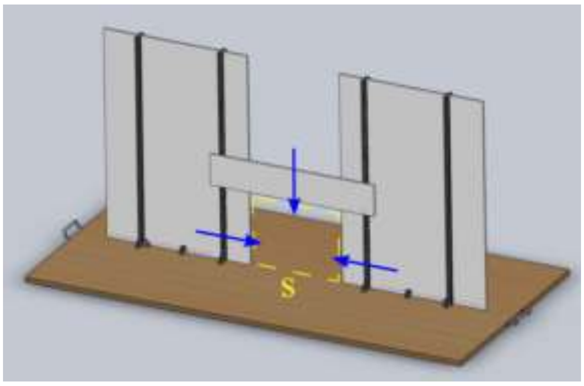


FIGURE 7: WALL TILE. BY MOVING THE PANELS, THE APERTURE WILL BE REDUCED TO MATCH ROBOT DIMENSIONS.

  Prior to the competition, the nominal robot dimension, r_d, (with respect to the locomotion direction) will be declared by the TL to the judges. When starting terrestrial race, the TL should inform the judges about how challenging the aperture should be for their robot, i.e. to which extent their robot is able to squeeze (or deform), and enter apertures smaller than r_d. The more the aperture is reduced, the highest the number of points that will be awarded for negotiating this obstacle. Approximately if $s = {}^{r_d}/_{1.1}$, base points are multiplied by 1.1, if $s = {}^{r_d}/_{1.2}$ base points are multiplied by 1.2 and so on. Scoring details are reported in the next section. Notice that it is possible even to reduce the score points by *increasing* the aperture dimension, but not exceeding 70 cm. If half of the body enters the aperture but the robot gets stuck, the task is considered partially solved.
- Task 3: The stair tile represent a simple 2-step stair (step height about 5 cm) which should be negotiate moving upward and downward. This is a classic task for robot locomotion. The task is considered partially solved if the robot is at least able to climb the stair, and it is instead considered completely solved if the robot is also able to climb down reaching back the ground.
- Task 4: The unstable environment tile is made of rubber tubes held in place by magnets. Rubber tubes represent the collapsible elements of the congested environment. The robot should pass inbetween the tubes without dislodging them.

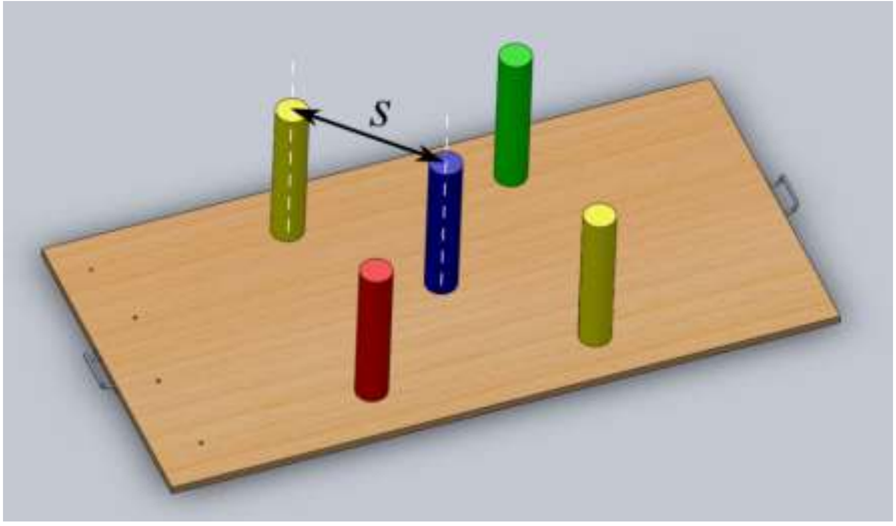


FIGURE 8: CONGESTED ENVIRONMENT TILE. THE RUBBER TUBES ARE MOVED TO MATCH ROBOT DIMENSION.

As in the wall tile, in this case the tubes should be moved to match the nominal dimension of the robot, r_d, so that the distance among the tubes, s, is approximately $s = r_d$. The robot could contact the tubes but should not push them away from their original locations. Tubes and magnets are described in the appendix section. If up to two tubes were dislodged, the task is considered partially achieved. If more than two tubes were dislodged, the task is considered not achieved. If no tubes are moved, the task is fully solved.

TIMING:

The maximum amount of time allowed for this task is 20 minutes.

GETTING POINTS:

Points are earned for the tasks:

- Negotiating the sand
- Negotiating the aperture
- Negotiating the steps
- Negotiating the unstable elements

MANIPULATION

GENERALITY:

In a structured environment, the robot should interact with several objects featuring complex shapes (possibly not known a priori) and different, possibly fragile materials, then it should move the manipulator to assume a suitable pose to apply a certain force to the object. This may represent industrial, surgical or domestic scenarios where the robot is required to manipulate particular objects or to inspect structures.

DESCRIPTION:

The scenario is structured into three tasks: pick and place of objects, arm positioning and door opening. This scenario is made of a structured environment as illustrated in Figure 8. Teams have two options to cope with the tasks: in the first one, the robot moves (thus it should be a mobile robot) toward the manipulation tiles and performs the demanded tasks. In the second option, teams are allowed to attach their robots, robotic arms or end-effectors to a linear slider (thus the robot could be also an arm-type robot).Technical specifications related to the latter option (maximum payload of the interface -connective plate- exact dimensions) are detailed in the appendix. There is no predefined order in which the tasks should be tackled. Each manipulation tile is itself a checkpoint: this means that once a task is completed or whenever the team desires, the robot could be moved from one tile to another.

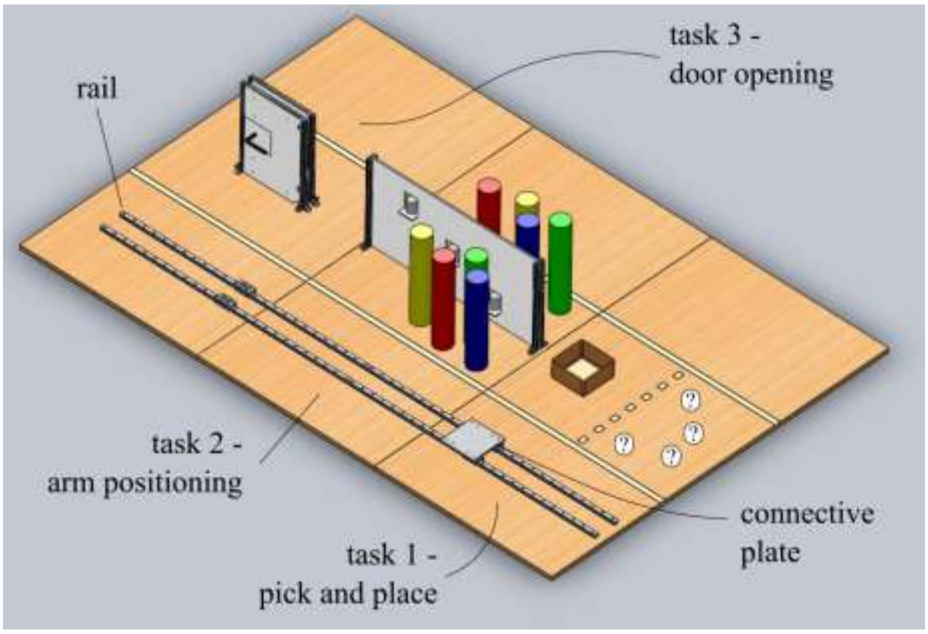


FIGURE 9: MANIPULATION SCENARIO. TASKS CAN BE APPROACHED FROM THE STRUCTURED SIDE, OR FROM THE UNSTRUCTURED ONE.

To attach the robot manipulator to the sliders, a *connecting platform* (connective plate in Figure 9) with blind holes will be provided. Each team should care of designing, bringing and fixing a *connective structure* fixing their robot to the connective platform. Two connection examples are shown in Figure 10. The connective platform is at fixed distance from the objects of the scenario: teams are free to reach the objects with their preferred connective structure.

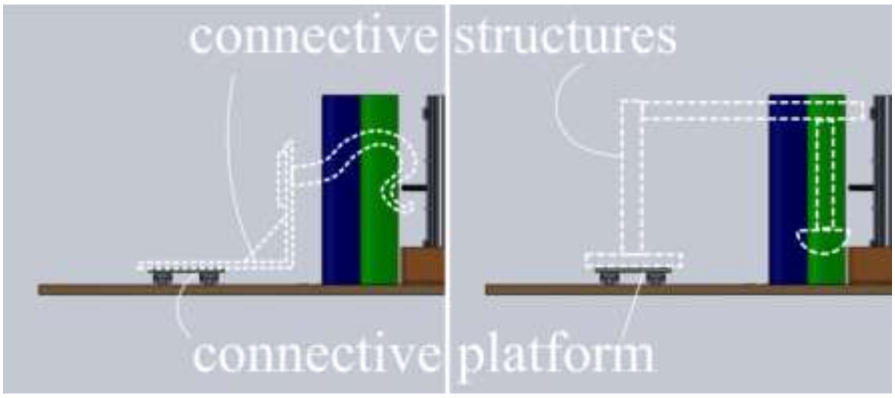


FIGURE 10: CONNECTION EXAMPLES. CONNECTIVE STRUCTURES CAN BE EITHER PASSIVE (AS IN THE LEFT FIGURE) OR ACTIVE (AS IN THE RR-ARM WITH A GRIPPER IN THE END OF THE RIGHT FIGURE).

SCENARIO DETAILS (BROKEN DOWN INTO TASKS):

- Task 1: The pick and place tile is made of two subspaces, one (a) where the objects (four different ones) are placed and the other (b) where the collecting basket is lodged. Objects form and material will be revealed the day of the challenge, however their maximum dimensions and weight are reported in the appendix section. Also fragile objects (glass-like or similar) could be presented.

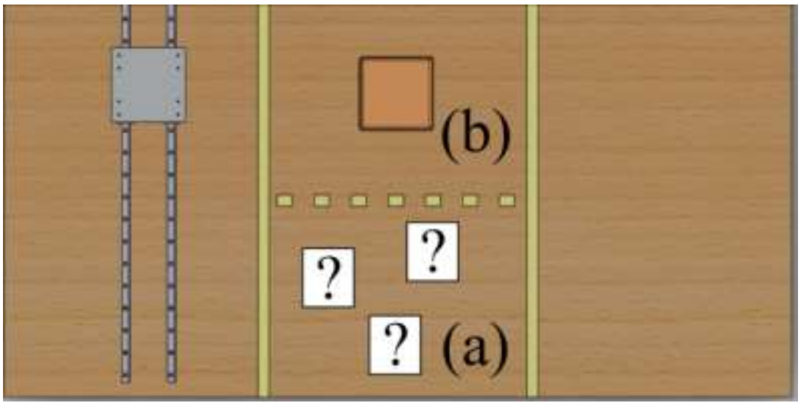


FIGURE 11: PICK AND PLACE TILE.

The objects should be collected inside the basket. Moving an object from side (a) to side (b) without succeeding in placing it into the basket worths a fraction of the points that will be earned with a correct placing inside the basket. If an object is damaged during the pick and place operation, the robot will not earn any point, no matter if it manages to move the object to the tile (b) or even placing the object into the basket.

- Task 2: In the positioning scenario, robots should demonstrate their dexterity by reaching three cans placed in a wall. The tile features three different lanes, from (i) to (iii). Robots should reach the cans by starting from a frontal position with respect to the can they have to touch. This is to prevent that a robot starts from lane (i) and touches the can of line (ii), avoiding the corresponding rubber tube.

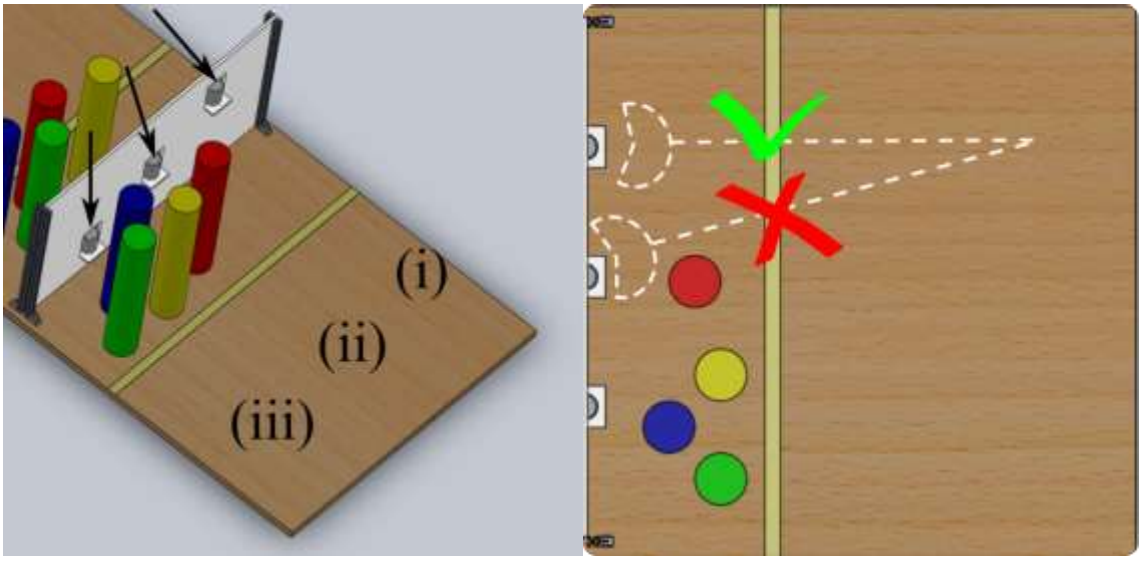


FIGURE 12: LANES OF THE POSITIONING SCENARIO. ON THE RIGHT, ALLOWED AND NOT ALLOWED PATH FOR THE MANIPULATORS.

The first lane (i) is the simplest one, as the robot can freely elongate to touch the can without the need to avoid any obstacle. In the second one (ii), a fixed rubber tube is placed between the can and the robot, thus that a low degree of dexterity is required by the manipulator. Finally in lane (iii) there are three rubber tubes between the can and the robot. The aim is to increase the difficulty of the task depending on the lane that is negotiated. If a manipulator passes the tubes but does not hit the can, the task is considered partially accomplished.

- Task 3: The door tile is made of a small door with an horizontal handle placed at mid height. Despite the apparent simplicity of the task, it requires coordination and strength both to achieve a stable grasp of the handle as well as during the opening maneuver. The task is considered completely solved if the handle is turned and door opened. Task is considered partially completed if the handle is rotated but door is not opened.

TIMING:

The maximum amount of time for this trial is 20 min.

GETTING POINTS:

Points are awarded for each element of the task completed:

- numbers of objects correctly picked-n-placed
- numbers of can reached
- door opened

UNDERWATER RACE

GENERALITY:

The robot is deployed in an underwater environment, comprising submersed relics, corals and algae. This scenario represents a fragile, unstructured environment which is not easily accessible by divers: the robot should move inside a confined space and operate selectively to dislodge seaweeds that are positioned close to fragile objects.

DESCRIPTION:

The robot is deployed from a platform about 50 cm far from the water. The robot should be resilient to this small "jump". The first task of this scenario is to navigate toward two buoys placed at different heights from the ground. The second task is to move inside an aperture that can be reduced or increased in dimension. The third task requires to remove the infesting algae without dislodging fragile elements (such as amphorae and corals).

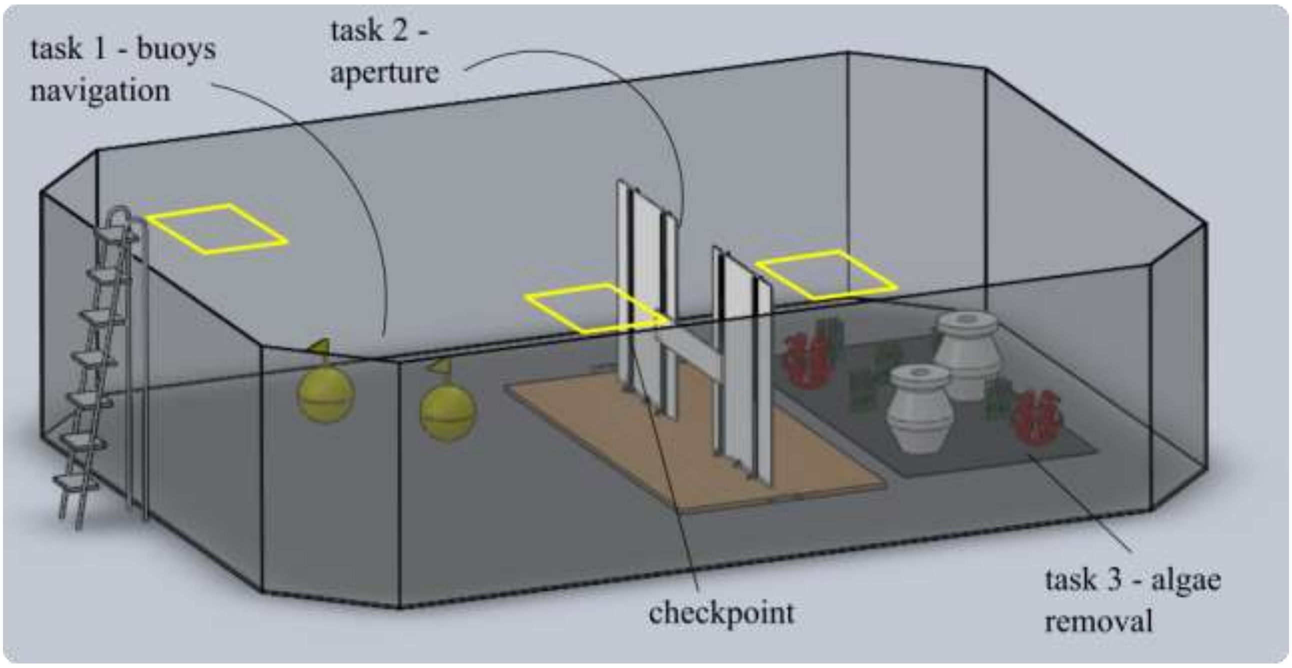


FIGURE 13: THE UNDERWATER RACE STARTS WITH A NAVIGATION PHASE, FOLLOWED BY A DEFORMATION TO ENTER AN APERTURE, AND FINISHES WITH A TILE INFESTED BY ALGAE, TO BE REMOVED WITHOUT DAMAGING FRAGILE OBJECTS NEARBY

SCENARIO DETAILS (BROKEN DOWN INTO TASKS):

- Task 1: The two buoys are placed respectively about 50 and 5 cm from the ground of the swimming pool, anchored to appropriate weights. Buoys are not fixed (a part of the anchoring cable) and can move by external actions. Moving close to the buoys but not hitting them awards a fraction of the total points.
- Task 2: The aperture to be negotiated is the same structure of Task 2 of the terrestrial race. All the rules valid for that task are directly applied here. Briefly recapping: walls are moved according to the team's will; points are multiplied by the reduction factor governing the size of the aperture relative to the characteristic dimension of the robot. The task is considered completed if the robot goes through the aperture and does not get stuck. If the robot goes through the aperture but

gets stuck, the task is considered partially achieved, as described for the terrestrial race.

- Task 3: Three types of objects are lodged onto a metal plate by magnets with different magnetic strength. The amphorae are fragile elements that are connected by high strength with the ground. The corals are fragile elements which are connected by low strength with the ground. The algae are infesting elements which are connected by low strength with the ground. The aim of the robot is to remove the infesting algae without dislodgning the fragile elements. Moving objects from their original location but not dislodging them awards half points.

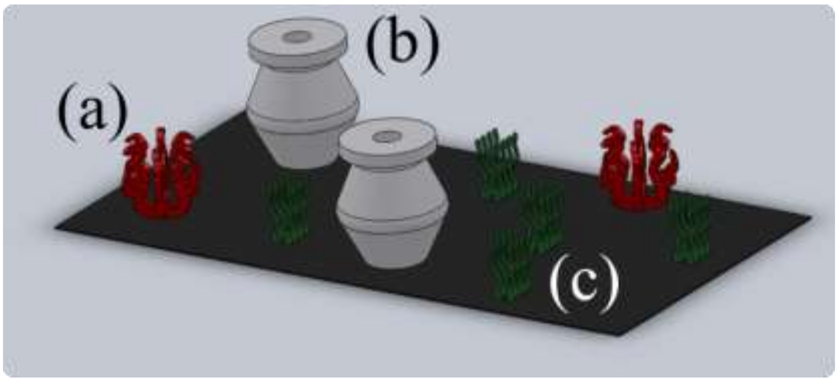


FIGURE 14: TILE WITH INFESTING ALGAE. ROBOT SHOULD REMOVE ALGAE (C) WHILE NOT DISLODGING OR MOVING CORALS (A) AND ANPHORAE (B).

The objects of this tile can be 3d printed or manufactured with other technology, however they will be made of hard material (such as PVC, PLA, ABS, wood, etc.). Overall dimensions and type of magnets will be reported in the appendix. The objects will have different colors (white for amphorae, green for algae, and red for corals) this will help the operator (or the robot itself, if autonomous) in distinguishing objects to be removed from those to be avoided.

TIMING:

The maximum time allowed for this scenario is 20 minutes.

GETTING POINTS:

After completing the scenario, or if the time expires, points are awarded for:

- Contact with the buoys
- Negotiation of the aperture
- Extirpation of the infesting algae
- Corals not dislodged
- Amphorae not destroyed

SCORING

Points are assigned for each task completed in each scenario. Each task can be evaluated as totally completed, partially completed, or not completed at all. Additional points are awarded for completing the scenario with a minimum amount of trials. Structured evaluation forms are provided to the judges to ease the score evaluation, see the following Scoring forms.

In the Scoring forms, the first column is the score awarded for not completing the task, second column is the score awarded for partially completing the task and third column is the score for totally completing the task. Third, fourth and fifth columns indicate scores for completing a task in the first, second or third attempt respectively.

TERRESTRIAL RACE

The scoring form for the Terrestrial Race is the following:

Terrestrial Race							
	not	half	full	1°	2°	3°	*m*
Task 1 - Sand	0	0,5	1	0,25	0,125	0	
Task 2 - Aperture	0	2	4	1	0,5	0	x
Task 3 - Stair	0	1	2	0,5	0,25	0	
Task 4 - Debris	0	2	4	1	0,5	0	
Total			13,75				

FIGURE 15: SCORING FORM FOR THE TERRESTRIAL RACE

Points are awarded for the four tasks described before. Additional points are awarded by completing the tasks in the first, second or third trial. Multiplying factors are applied depending on the aperture decrease/increase.

Terrestrial Race								
	not	half	full	1°	2°	3°	m	
Task 1 -Sand								1,25
Task 2 -Aperture							1,1	2,75
Task 3 - Stair								1,25
Task 4 - Debris								0
Time	x							
Total			5,25					

FIGURE 16: EXAMPLE OF A FILLED-IN SCORING FORM

The total amount of points earned are the sum of the points marked in the scoring form, as in Figure 15. A filled-in scoring form is presented in Figure 16: on sand, the robot completely achieved the task (+1 point) in the first trial (+0.25 point), see partial on the left of 1.25 points. On aperture task, it partially completed the task (+2 points) in the second attempt (+0.5 point) with a multiplier of 1.1, thus the partial score is 2.75. By adding scores achieved in the other tasks a final score of 5.25 is obtained. Completion time is reported and will be evaluated only if teams scores are equal.

MANIPULATION

Scoring for manipulation and underwater scenarios follows the same principles of the terrestrial race.

Manipulation						
	not	half	full	1°	2°	3°
Task 1 - Object 1 hanlded	0	0,5	1	0,25	0,125	0
Task 1 - Object 2 hanlded	0	0,5	1	0,25	0,125	0
Task 1 - Object 3 hanlded	0	1	1	0,25	0,125	0
Task 1 - Object 4 hanlded	0	1	1	0,25	0,125	0
Task 2 - Can 1 reached	0	0,5	1	0,25	0,125	0
Task 2 - Can 2 reached	0	0,75	1,5	0,375	0,1875	0
Task 2 - Can 3 reached	0	1	2	0,5	0,25	0
Task 3 - Door opened	0	1,5	3	0,75	0,375	0
Total			14,375			

FIGURE 17: SCORING FOR THE MANIPULATION SCENARIO

UNDERWATER RACE

As in the terrestrial race, in the underwater one thescore for Task 2 is multiplied by the reduction factor of the aperture. Notice that in Task 3 there are 4 algae to be eradicated, and 4 object to preserve. Each alga will be associated with one fragile object: the points for not damaging a fragile object is earned only if the associate alga is eradicate. This is to avoid attributing points related to not damaging fragile objects even if the robot is not able to perform any meaningful action.

Underwater Search							
	not	half	full	1°	2°	3°	*m*
Task 1 - Buoy 1 hit	0	0,5	1	0,25	0,125	0	
Task 1 - Buoy 2 hit	0	0,5	1	0,25	0,125	0	
Task 2 - Aperture	0	2	4	1	0,5	0	x
Task 3 - Algae 1 eradicated	0	0,25	0,5	0,125	0,0625	0	
Task 3 - Algae 2 eradicated	0	0,25	0,5	0,125	0,0625	0	
Task 3 - Algae 3 eradicated	0	0,25	0,5	0,125	0,0625	0	
Task 3 - Algae 4 eradicated	0	0,25	0,5	0,125	0,0625	0	
Task 3 - Amphora 1 not damaged	0	0,5	1	0,25	0,125	0	
Task 3 - Amphora 2 not damaged	0	0,5	1	0,25	0,125	0	
Task 3 - Coral 1 not damaged	0	0,5	1	0,25	0,125	0	
Task 3 - Coral 1 not damaged	0	0,5	1	0,25	0,125	0	
Total			15				

FIGURE 18: SCORING FOR THE UNDERWATER RACE

ACKNOWLEDGMENTS

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APPENDIX

Appendix reports the list of material that will be used to build the scenarios, the approximate dimensions and other details regarding the competition field. This is to increase the understanding of the scenarios and also to allow the teams to reproduce scenarios or parts of them. As for all the part of this rule book, also this part can be subject to modification, even if this is not envisaged by the organizers. Additionally, all CAD of the scenario will be available for download, inspection, or usage by the team. Readers should be aware that the organizers do not take the responsibility of small discrepancies among the CAD and the actual scenarios. Please also note that some of the CAD models are from third parts, which own the rights on them.

Approximate dimensions of the fields are presented in the following drawings, which provide a broad understanding of the scenario size. Essential components to build and assembly the scenarios are provided hereafter. Scenarios are made of commercial components, so that each participant can easily buy them and check features of interest (weight, adhesion force, maximum payload, ect.). This is to allow participants to replicate scenarios (or part of them) in simulation or physically. Although the organizers are trying to be more specific as possible, be aware that modifications to the proposed implementations, due to logistics, are conceivable. Clarification about rules are also reported.

TERRESTRIAL SCENARIO

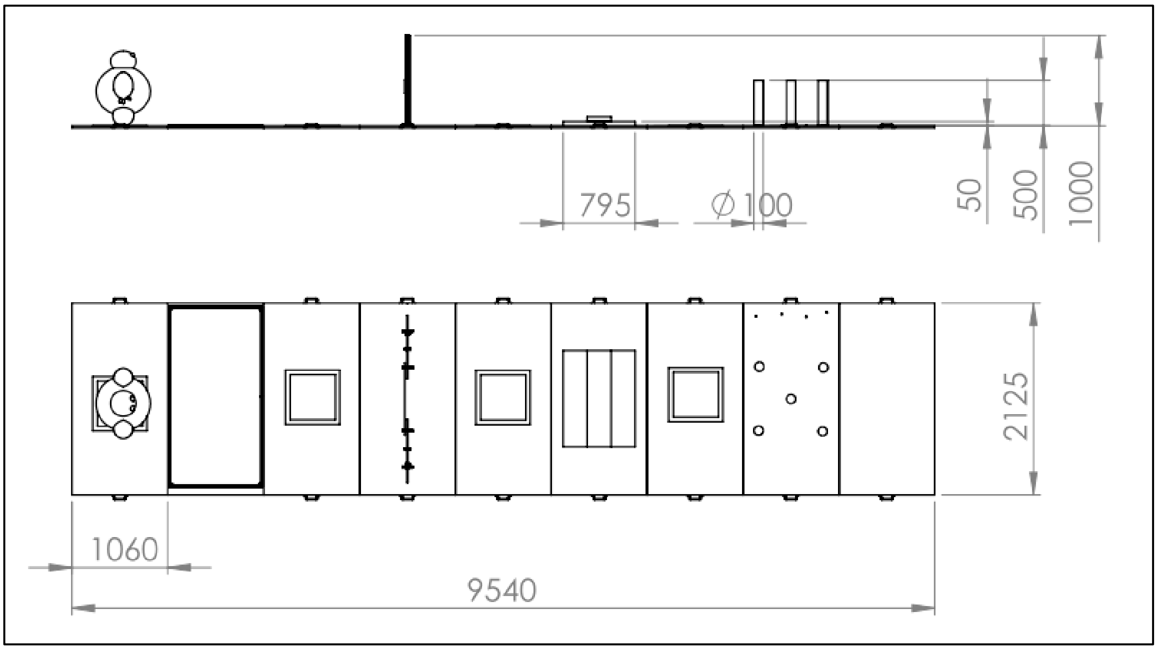
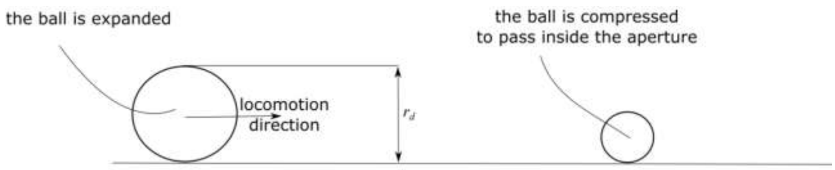


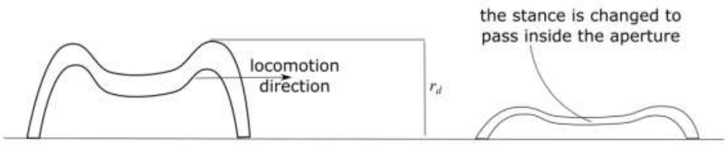
FIGURE 19: TERRESTRIAL RACE DRAWING. SCALING 1:75. MEASURES IN MM.

The material of the floor will be wood: our plan is to use a commercially available tile (Leroy Merlin, ID OBJ 35198730 http://www.leroymerlin.it/ricerca?q=35198730). Steps for the stair tile will be obtained from the same wood plate. All structural components (sand and aperture tiles) will be made of MISUMI aluminium frame, HFS5-2020-1000[2] and HFS5-2020-1000. The sand tile could be slightly uneven with respect to the previous one, however the maximum high of the step should be lesser than 40mm. The dimension of the sand is intentionally unspecified (it could range from fine sand to a few millimetres granules). Tubes of the debris tile will be foam noodles from Decathlon http://www.decathlon.it/noodle-di-schiuma-120cm-id_8216134.html. We plan to connect tubes to the ground with FE-S-10-03 magnets from supermagnete.it http://www.supermagnete.it/eng/disc-magnets-ferrite/disc-magnet-diameter-10mm-height-3mm-ferrite-y35-no-coating_FE-S-10-03. This is the attaching force that participant should consider. Teams should keep in mind that a force applied radially with respect to the axis of the tube can translate the noodle in another position where magnetic force will be reduced.

Aperture tile needs more specification with respect to the nominal robot dimension. This is a critical measure which is interesting because it highlights deformability of soft robots, but also it is complex because could be extremely qualitative. We try to make it as fair and quantitative as possible by using these considerations: teams will declare the locomotion direction of their robots, and we use the frontal projection with respect to the robot direction. The maximum dimension of the frontal section will be used as r_d. Robots will be evaluated in one of the stance (if robots are able of multi-modal locomotion) used for locomotion, decide by the teams, and robots are allowed to change stance to enter the aperture. Judge will supervise and approve the participants evaluation, to ensure the fairness of the comparison among different robots. Teams should consider that due to the soft robots variability this evaluation could be extremely complex: in case of discrepancies among participant and judge evaluations, the latter one will be used for the calculation of the points.

Here we report two examples, which illustrates actual soft robots, to explain the concept. The first one is the JSEL[3] robot, that I depict as a ball, the second is a lateral view of a pneumatic legged robot[4].





[2] Important notice: product codes are referred to the Italian suppliers. Other countries' suppliers can provide a different code for the same product, so check carefully specifications.

[3] Steltz, E.; Mozeika, A.; Rodenberg, N.; Brown, E.; Jaeger, H.M., "JSEL: Jamming Skin Enabled Locomotion," in *Intelligent Robots and Systems, 2009. IROS 2009. IEEE/RSJ International Conference on* , vol., no., pp.5672-5677, 10-15

[4] Ansari, Y., Shoushtari, A.L., Cacucciolo, V., Cianchetti, M., Laschi, C., *Dynamic walking with a soft limb robot*, LNCS, 2015

It is extremely important that participants keep in mind that the aperture will be a square, so that the reduction will affect two orthogonal dimensions.

MANIPULATION SCENARIO

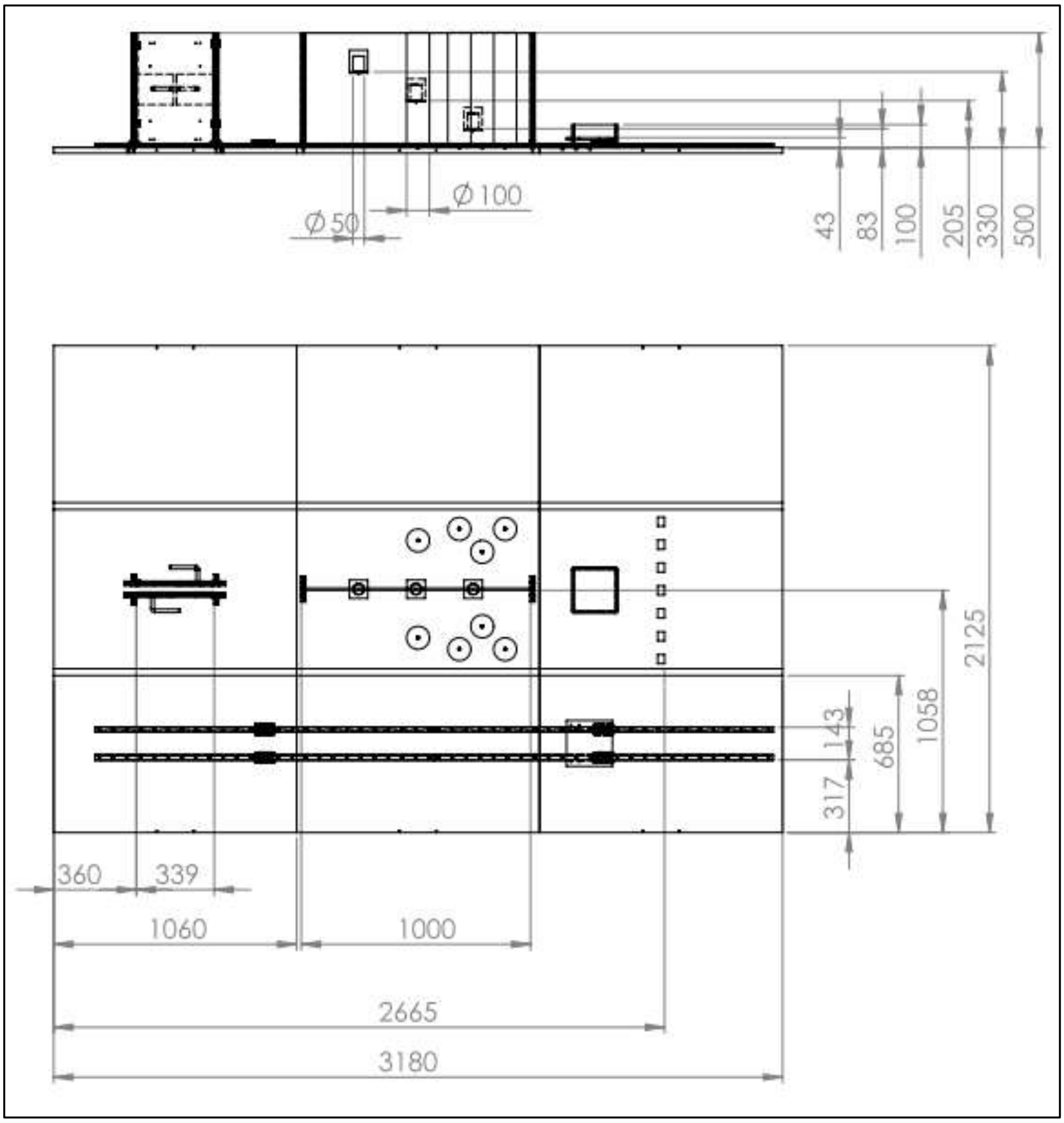
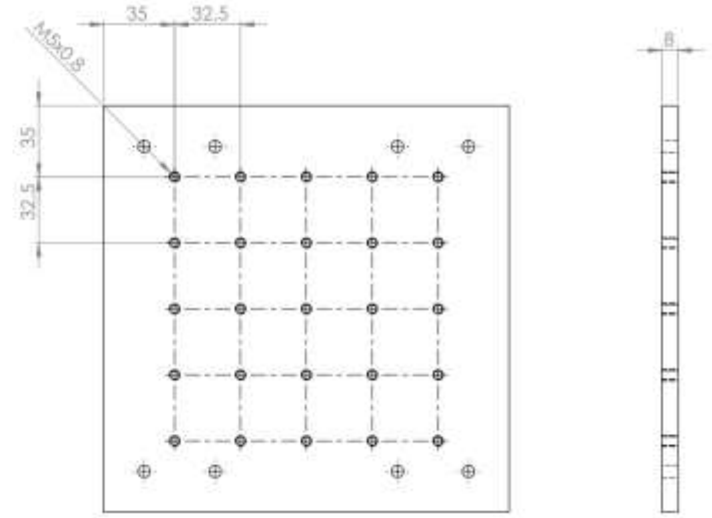


FIGURE 20: MANIPULATION DRAWING. SCALING 1:25. MEASURES IN MM.

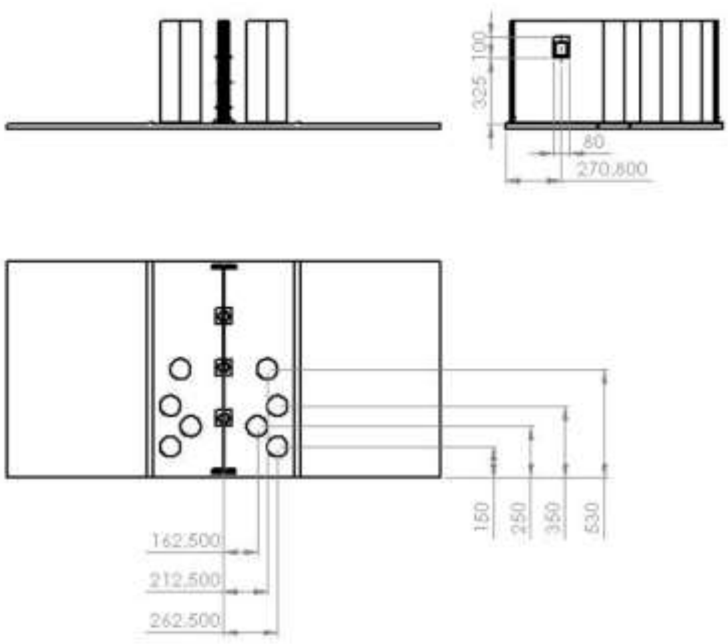
The material of the floor will be wood: our plan is to use a commercially available tile (Leroy Merlin, ID OBJ 35198730 http://www.leroymerlin.it/ricerca?q=35198730). All structural components will be made of MISUMI aluminium frame, HFS5-2020-1000[5] and HFS5-2020-1000. The rail and slider are commercial components from MISUMI, SXR33-1480. The connecting platform will be attached to the sliders and will have several holes to attach the other structures. Maximum dimensions of the plate are 200x200mm. A grid of M5 holes is provided to attach the arms (and/or structures) to the sliders. Larger holes (8 external holes on the edge of the platform) are used to attach the platform to the sliders, so consider just the grid. Please keep in mind the overall payload and the other

[5] Important notice: product codes are referred to the Italian suppliers. Other countries' suppliers can provide a different code for the same product, so check carefully specifications.

specifications of the sliders. Exact positioning of the holes are reported in the following schema, dimensions in mm.



The objects to be collected will have a maximum weight of 1Kg and will be contained in a bounding box (a cube) of approximately 100mm side, but shape, materials and positions will be revealed the day of the challenge. Collecting basket will be box-like containers with dimensions of 200x200x100mm. The robot is supposed to go through the tubes in lane (iii) of task2. Passing on the side is allowed in lane (ii). Tubes will be foam noodles from Decathlon http://www.decathlon.it/noodle-di-schiuma-120cm-id_8216134.html that will be fixed to the ground. Here a detailed drawing of the positions. Dimensions in mm.



In the task3, the door should be pulled (the other direction is blocked), but consider that required angle of opening is very small. To score points, it is sufficient that the door is opened of 5° (basically the handle is rotated and the door is slightly opened). Here the main objective is to demonstrate that manipulators can simultaneously apply a torque to the environment and have a certain degree of dexterity. About the torque to be applied, we plan to use a commercial locker/handle, again from Leroy Merlin, so you can take as a reference those handles/lockers.

UNDERWATER SCENARIO

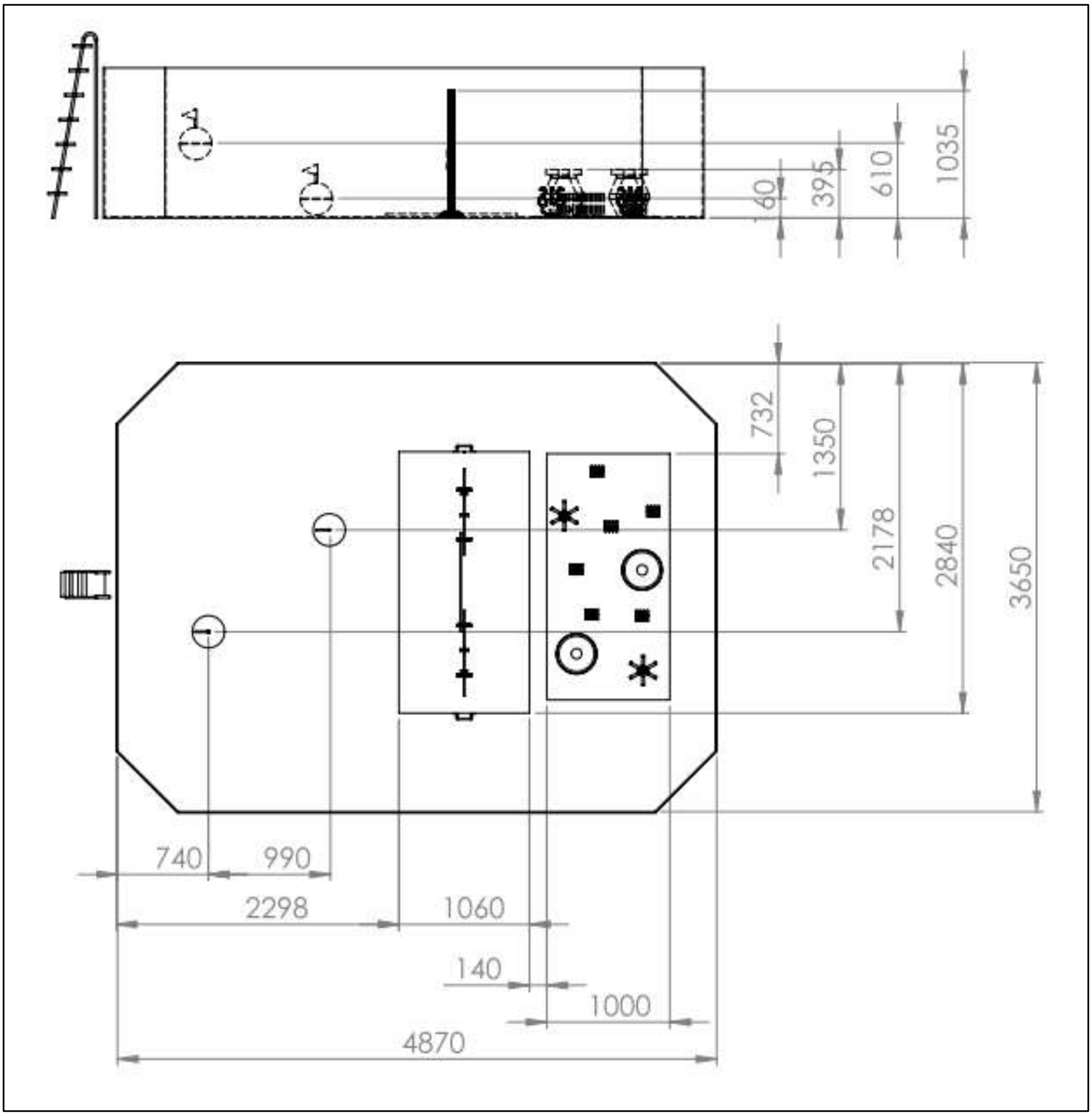


FIGURE 21: UNDERWATER RACE DRAWING, SCALING 1:50. MEASURES IN MM.