THE EUROPEAN EXCELLENCE NETWORK
ON AI-POWERED ROBOTICS

euROBIN Coopetition 2024

Rules & Regulations

Version: 2024
Last Build Date: March 8, 2024

About this rulebook

This is the official rulebook of the euROBIN coopetition 2024 that will take place in Nancy, 25-28 November 2024.

How to cite this rulebook

Acknowledgments

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Chapter 1

Introduction

1.1 euROBIN Project

euROBIN is the European Network of Excellence on AI-powered Robotics. As the single Network of Excellence (NoE) focused on robotics within the NoE initiative, it has as a goal to integrate the scientific and technological excellence of Europe in this field.

euROBIN identified and addresses, as a main scientific and technological challenge hampering the breakthrough of robotics, the transferability of cognition-enabled robotics methods between systems and among scientific partners and companies. This overarching goal has been selected because it can best benefit from the network nature of the project, which includes a large number of outstanding scientific partners (26) that contribute in-kind with some world-leading robotics systems. It is a premise of the project that each partner already brings in, with its own systems, a set of methodologies and skills which allows solving some of the application challenges at state-of-the-art level. The main question we address in the project is to develop methodologies, infrastructures and incentives to transfer methods and data between different robots and different applications.

1.2 Hackathons and Coopetitions

The euROBIN network proposes the novel concept of robot cooperative competition focused on the three main application domains defined in the robotics roadmap of Horizon Europe:

- Robotic manufacturing for a circular economy
- Personal robots for enhanced quality of life and well-being
- Outdoor robots for sustainable communities

Each application domain correspond to one coopetition league. The leagues are described in Section 2.4.

euROBIN's cooperative competitions are based on a scoring system, described in Chapter 2, that gives credit to a team for its own achievements in executing tasks and for the successful usage by other teams of modules developed by the team. The latter approach promotes cooperation. In the limit, a team that produces very successful modules used by many other teams might win the competition without developing its own integrated system. Nevertheless, teams are encouraged to impact both components, actively participating in the actual coopetitions. The project team has been working on developing metrics that enable to award score points to teams contributing with modules used successfully by other teams in the coopetitions, effectively encouraging module transferability and reusability. Developed modules must be available in euROBIN's EuroCore platform.

Hackathons will me held mostly online, using realistic simulators developed within the project, namely the Virtual Research Building. They will serve to let the teams prepare for euROBIN's two major coopetition events: in Nancy, France, after Humanoids 2024, and in another event close to the end of the project, in 2026.

The first euROBIN project hackathon has been held in Seville in May 2023, lasted one week, and was based on real robots and a realistic lab scenario. The aim of the first hackathon was to pave the road for building EuroCore and testing the transferability of robotic features among the project partners. A video with a final hackathon demo can be seen in https://youtu.be/vrRwY7f0g8I?si=sYf3rzEIy3J4r3_Q.

1.3 Modularity and Transferability

Teams (internal and external to the project) participating in euROBIN coopetitions are strongly advised to contribute with methodologies and software modules which are modular, so as to promote transferability across robot platforms and across applications as much as possible. Modularity also promotes compositionality. All these are desirable requisites to build complex robot systems, and the goal of euROBIN coopetitions is to identify the best practices on modularity that lead to transferability and compositionality, and turn them into practical modules that can be used in the robot systems of the future.

Chapter 2

Coopetition General Rules and Regulations

This section introduces the coopetition structure and stages, and the overall rules. The coopetition is divided into two stages: the Marketplace phase and the On-Site Coopetition phase. The Marketplace phase takes place some months before the On-Site Coopetition phase and allows the participating teams to exchange software modules and collaborate. During the On-site Coopetition the teams compete with each other by solving multiple tasks with their robots. The EuroCore platform provides the required infrastructure during the coopetition, to enable and track module transferability during the Marketplace phase, and to track the scores during the On-Site phase.

In this coopetition model, an equal amount of tokens are initially allocated to each team. These tokens serve as currency for module transactions and as points for the teams' final coopetition score. During the initial Marketplace phase, teams can purchase and sell software modules from other teams with these tokens. The teams with more tokens by the end of the Marketplace phase start the On-Site coopetition with more points. During the On-Site coopetition, teams that integrate modules from other teams will see their scores multiplied by 10 each time they achieve a milestone using these modules.

Sections 2.1, 2.2, and 2.3 provide further detail for the EuroCore platform, the Marketplace phase and the On-Site phase, respectively. Section 2.4 provides an overview of each league.

2.1 EuroCore

One of the main goals of EuroCore is to provide a platform that fosters collaboration between teams and enables software module transferability. EuroCore enables teams to share their software, data, and expertise, as well as to provide comprehensive descriptions of their respective teams and robotic platforms. Moreover, EuroCore is instrumental in orchestrating the Coopetition, facilitating the systematic tracking of the teams' overall performance.

Structured into four layers, the EuroCore comprises the Module and Data Transfer Layer, the Robot Description Layer, the Teams Description Layer, and the On-site Coopetition Layer, as depicted in Figure 2.1.

The Module and Data Transfer Layer, enables teams to upload and test each other's software and data assets. This layer has detailed insights into the origin of uploaded modules, adherence to established standards when applicable, and the availability of integration support by the team that is providing the module. Furthermore, it also tracks module transactions between teams, setting up the score accordingly. The Module and Data Transfer Layer also provides information regarding user feedback and the cost of integration support for each module. Figure 2.2 illustrates this layer with an example, where Team A offers a navigation module that costs 1000 tokens, and Team B purchases this module and integrates it into its' robot. In this process,

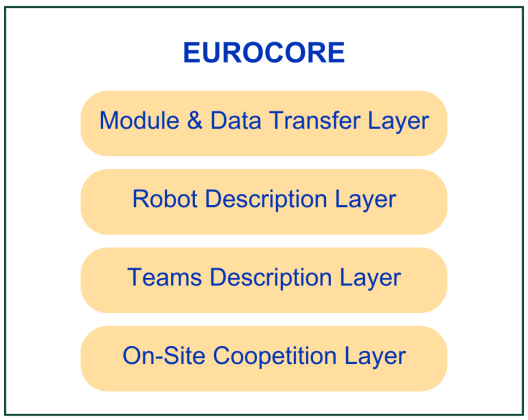


Figure 2.1: EuroCore Design.

Team A gets an extra 1000 tokens that it can use to purchase other modules or keep it and start the on-site phase with these extra points.

The example also demonstrates how teams can offer module integration support to other teams testing their modules, thereby earning more tokens. Teams are responsible for setting their own integration support costs. Figure 2.2 illustrates an example where Team A's navigation module offers integration support at a cost of 100 tokens.

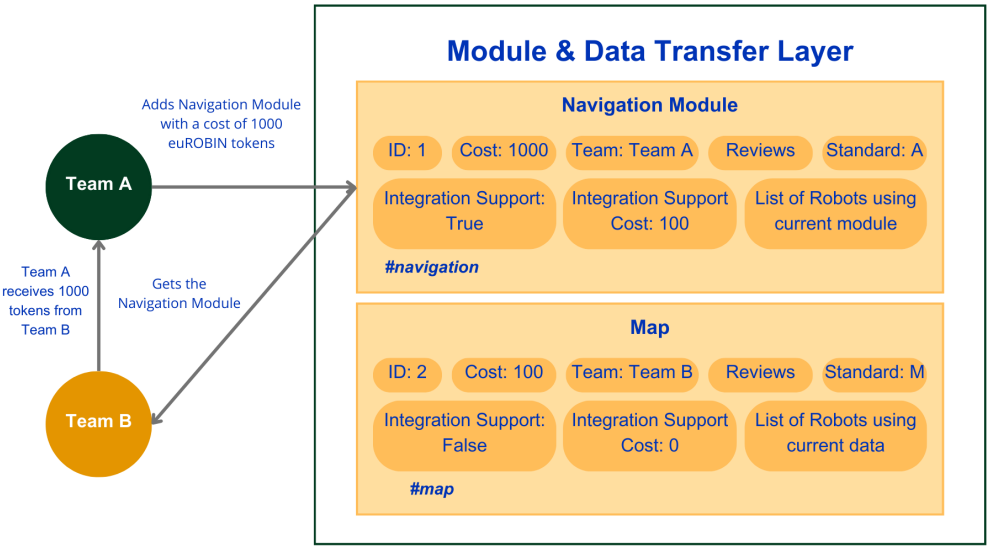


Figure 2.2: Module and Data transfer layer. This figure depicts one example where Team B buys Team's A navigation module.

These tokens have no relation to any financial asset or real-world currency, and consequently each transaction only has repercussions in the coopetition score and each team's ability to purchase modules. Furthermore, teams can attempt the integration of all the modules before committing to the purchase. However, until the last day of the Marketplace phase, the teams must state through, the EuroCore platform, which modules they intend to use during the On-Site

phase.

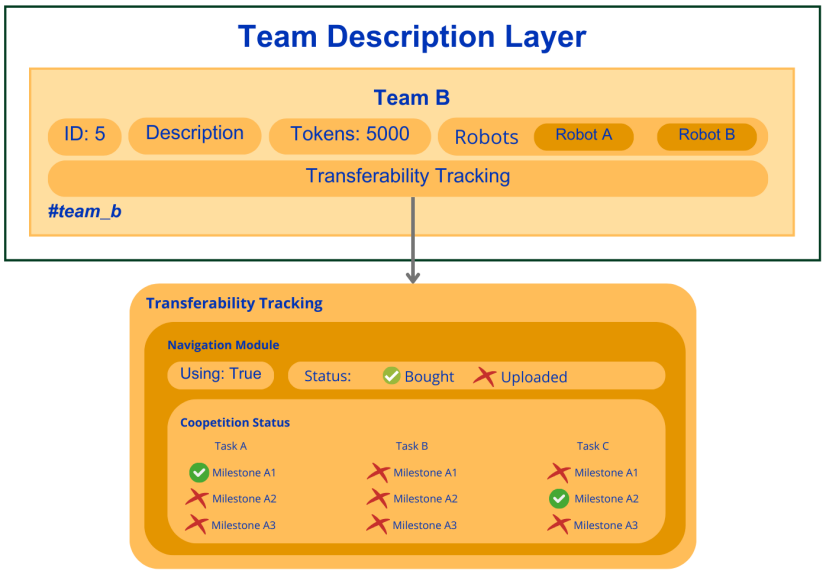


Figure 2.3: Teams description layer.

The Team Description Layer, as illustrated in Figure 2.3, provides a comprehensive overview of the participating teams, encompassing their token allocation, robotic platforms, and module utilization. This layer allows the teams to detail the origin and in which milestone the purchased modules will be used. This will have repercussions on the scoring system, as for those milestones the maximum scoring will be multiplied by given factor, for the team using other team's modules.

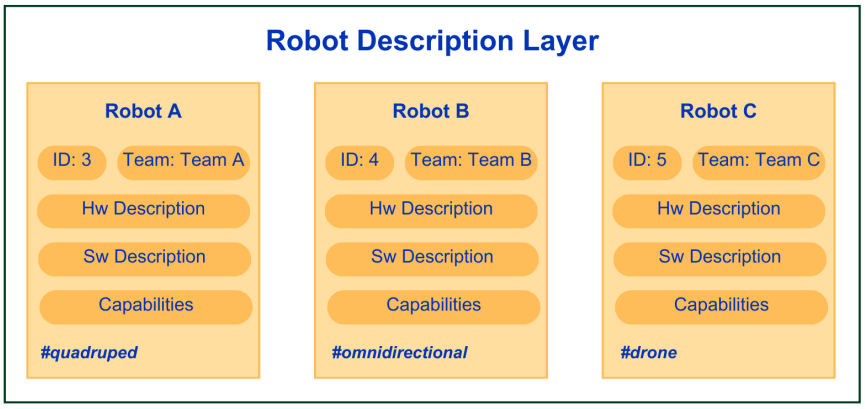


Figure 2.4: Robot description layer.

The Robot Description Layer provides details about the robots participating in the Coopetition. Each robot entry includes information about its hardware, software, such as the software modules utilized on the platforms, and their functionalities. Sharing this knowledge aids teams in understanding the requirements necessary to execute and test modules from other teams.

Moreover, it allows teams to become acquainted with various robotic platforms in terms of hardware. This layer is especially valuable for teams considering participation in the Coopetition without bringing their own robot. They can refer to the list of robots to assess which one aligns best with their software pipeline, aiding in the decision-making process regarding the use of other teams' robotic platforms. Figure 2.4 illustrates this layer.

The On-Site Coopetition Layer, depicted in Figure 2.5 will showcase the coopetition results, allowing teams to track their scores live as the coopetition unrolls.

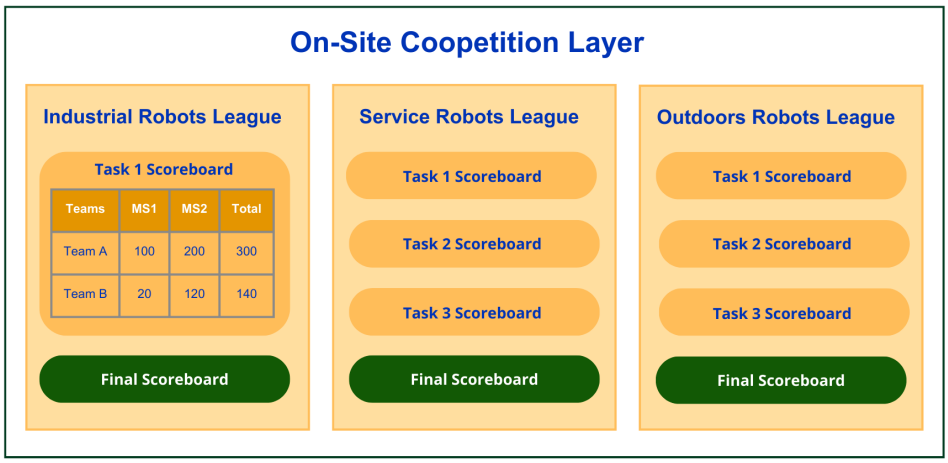


Figure 2.5: On-Site Coopetition layer.

2.2 Marketplace Phase

The Coopetition initially allocates a set number of tokens to teams, which function as the currency for module transactions. During the Marketplace Phase, teams have the freedom to trial modules on their robotic platforms without any "financial" obligation.

As the On-Site Coopetition unfolds, the system transitions to a procurement model where teams engage in transactions involving software models, data, or pertinent information, such as semantic maps. Each team is responsible for tracking the transferability of acquired modules, by specifying the origin and utilization context within EuroCore's Teams Description Layer, as described in Section 2.1. Teams are required to communicate this information through Eurocore by the last day of the Marketplace phase. Additionally, teams have the opportunity to earn more tokens by providing integration support for their assets if necessary.

2.3 On-Site Coopetition

The On-Site Coopetition comprises two distinct stages: Task Demonstration and Robot Skill Bazaar. During the Task Demonstration stage, teams are assigned specific tasks based on their

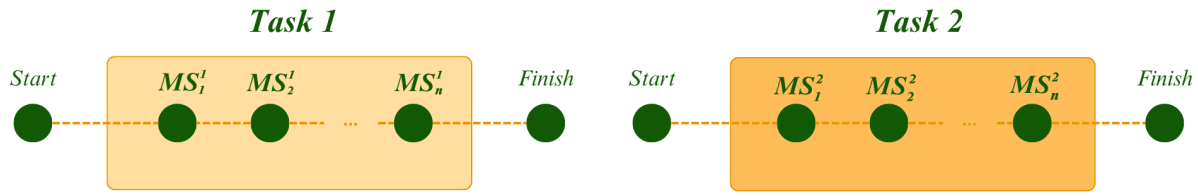


Figure 2.6: Suggested task design where tasks are divided in several milestones MS_n^i.

The second stage of the On-Site Coopetition is the Robot Skill Bazaar. This stage serves as an Open Challenge platform where teams can showcase their robot skills and promote them via EuroCore. Additional details regarding this stage can be found in Section 2.3.3.

2.3.1 Scoring System

As previously discussed, tasks are segmented into multiple milestones as depicted in Figure 2.6, each potentially differing in difficulty and conditional level. In this sense, Equation 2.1 serves as a metric for evaluating the comprehensive execution and efficacy of a milestone.

$$MS_n^i = \left(b_{m_n} l_{m_n} \left(1 + \frac{q_{m_n}}{50} \right) \left(9 I_{transfer} + 1 \right) - p_{m_n} \right) I_{success} \tag{2.1}$$

The terms in Equation 2.1 have the following meaning:

- i is the task number.
- n is the milestone number.
- $b_{m_n} \in \mathbb{N}$, is the number of tokens received for achieving successfully milestone n.
- $l_{m_n} \in [0, 1]$, relates to the milestone's condition level, and it represents the varying degrees of complexity associated with the milestone. Mathematically, it is designed as a factor that caps the maximum amount of points that can be awarded per milestone.
- $q_{m_n} \in [0, 10]$, denotes the subjective sub-scoring attributed to the milestone. An external referee will evaluate the quality and efficiency of the behavior exhibited in task execution, assigning a score ranging from 0 to 10. This sub-scoring component has the potential to augment the total milestone score by an additional 20%.
- $I_{transfer} : M \rightarrow \{0, 1\}$, serves as an indicator, taking the value of one when the team utilizes a module from another team to accomplish the milestone, and zero otherwise. Consequently, the scoring increases by 1000% in cases where module transferability is observed.

- $p_{m_n} \in \mathbb{N}$, refers to the penalties incurred during each milestone execution. For instance, during navigation, each collision reduces the milestone score by $p^i_{m_n}$, where $p_{m_n} = \sum_i p^i_{m_n}$. Note that a milestone score can only be negative due to an excessive amount of penalties, as the values of the remaining coefficients are chosen to prevent negative scores.
- $I_{success} : M \to \{0, 1\}$, indicator function assuming the value one when the milestone was achieved with success, and zero otherwise. This means the total score is zero when the milestone is not achieved.

This scoring methodology considers not only the milestone's inherent difficulty and contingent complexity but also incorporates subjective assessments by non-technical referees, possibly including audience feedback. Moreover, Equation 2.1 provides rewards in instances of confirmed module transferability, wherein a team employs another team's module to fulfill the milestone. Additionally, penalties and the overall success of milestone execution are taken into consideration.

The task final score can be computed as:

$$S^i_{task} = \sum_{n=1}^{N} MS^i_n \tag{2.2}$$

where,

- MS^i_n is the milestone n score from task i
- $N \in \mathbb{N}$, is the total number of milestones in task i,

and the sum of all task scores can then be computed as,

$$S_{execution} = \sum_{i=1}^{S} S^i_{task} \tag{2.3}$$

where,

- $S \in \mathbb{N}$, is the total number of tasks
- S^i_{task} is the score of task i,

and $S_{execution}$ represents the teams On-Site Coopetition score. The team's final score is given by the sum of the On-Site Coopetition score $S_{execution}$ and the number tokens resulting from the Marketplace Phase $S_{marketplace}$, as depicted in equation 2.4.

$$S_{coopetition} = S_{marketplace} + S_{execution} \tag{2.4}$$

Figure 2.7 aims to give a concise depiction of the interconnections between various systems. Upon examination of this illustration, one can understand the process by which teams upload their information and assets to the Module and Data Transfer, Robot Description, and Teams Description Layers while engaging in competition within the arenas. Meanwhile, the On-Site Coopetition Layer interfaces directly with entities responsible for task assessment, such as arena taskboards, referees, and Coopetition designers.

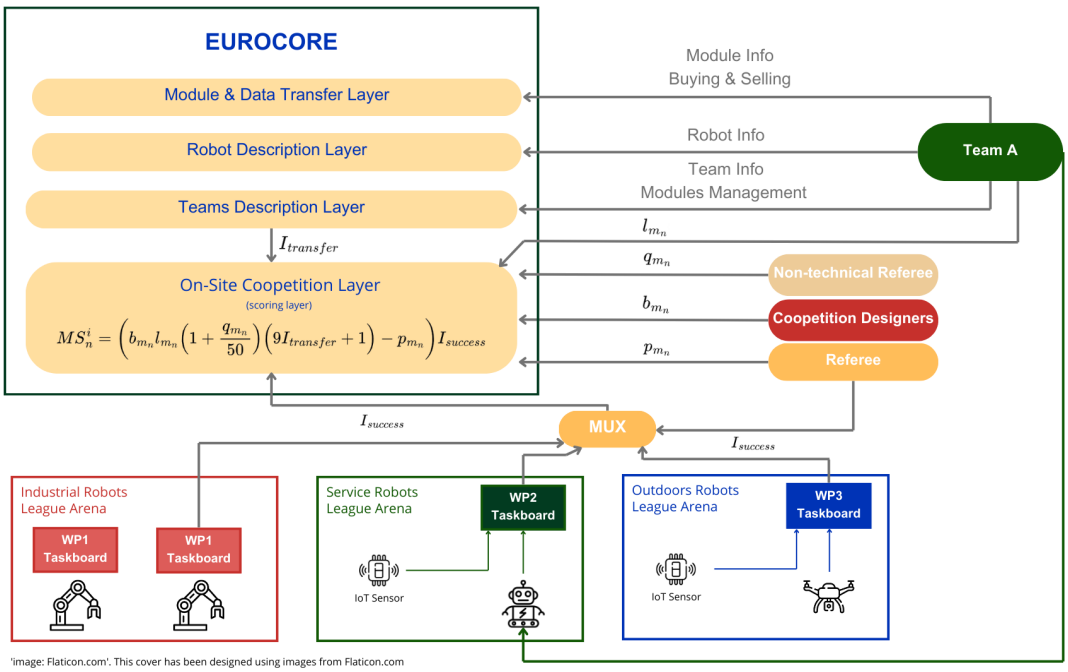


Figure 2.7: On-Site Coopetition general overview. It's important to note that the values of b_m, l_m, and p_m will be determined by the Coopetition Designers before the On-Site Coopetition. However, it's up to the team to specify their milstone condition level l_m at runtime. Referees will also determine which penalties p_m to apply based on the team's milestone execution.

2.3.2 Task Demonstration

In this phase of the Coopetition, teams will encounter tasks of varying difficulty levels tailored to different types of robotic platforms, including industrial, service, and outdoor robots. Each task will be performed in designated arenas, as illustrated in Figure 2.7, targeting specific testing functionalities and skills corresponding to the robot type.

As outlined in the preceding section, tasks are subdivided into multiple milestones, which may differ in their conditional complexity. The Coopetition designers will define the conditional levels of the milestones, along with all pertinent information regarding penalties and fixed scores. During the On-Site Coopetition, particularly at task execution time, teams must specify the conditional level they are aiming for, while referees are tasked with assigning penalties. Non-technical evaluators, such as members of the audience, will be invited to provide subjective scores for the milestones and tasks, focusing on the quality and efficiency of execution.

2.3.3 Robot Skill Bazar

After the task demonstration, teams will exhibit their robot skills and market them through EuroCore in the Robot Skill Bazar. Teams must provide a comprehensive explanation of the showcased skills, along with specifying the software and hardware requirements necessary to run the modules on their robots. The jury and referees will evaluate and vote on the best modules, by ranking the teams.

Ranking	**Tokens**
1^{st} place	X_1
2^{nd} place	X_2
3^{rd} place	X_3

Table 2.1: Scoring system for the Robot Skill Bazar.

This challenge is also an opportunity for the teams to showcase their modules and persuade the remaining teams to use their modules in future coopetitions.

Points will be awarded to the teams based on their ranking, with the first-place team receiving X_1 points, the second-place team receiving X_2 points, and the third-place team receiving X_3 points, as defined in Table 2.1

2.4 Leagues

- The coopetition is divided into three leagues: the Industrial Robots League, the Service Robots League, and the Outdoors Robots League.
- The Industrial Robots League is a league oriented for robotic manipulation and tasks encompass challenges in this field.
- The Service Robots League aims to advance technology and science for service and assistive robots, with particular emphasis on personal and domestic applications.
- The Outdoors Robots League encompasses challenges for both aerial and ground robots in mixed indoor and outdoor environment.

- Each league has its own set of tasks and milestones, despite following a similar structure of the general rules.
- The same team cannot register and compete under the same name in more than one league, assuming that they comply with the specific rules of each league.
- If the same team wants to participate in more than one league it must register with different names and apply for both leagues.
- The scoring for each league is separate and teams only compete against the teams in their own league.
- At the conclusion of the Coopetition, a winner will be determined for each league. The winning teams will be those who accumulate the highest number of tokens across the Marketplace phase, Task Demonstration, and Robot Skill Bazaar within their respective leagues.
- The Coopetition will take place at the Nancy Congress Center. Figure 2.8 illustrates the space allocation for each league.

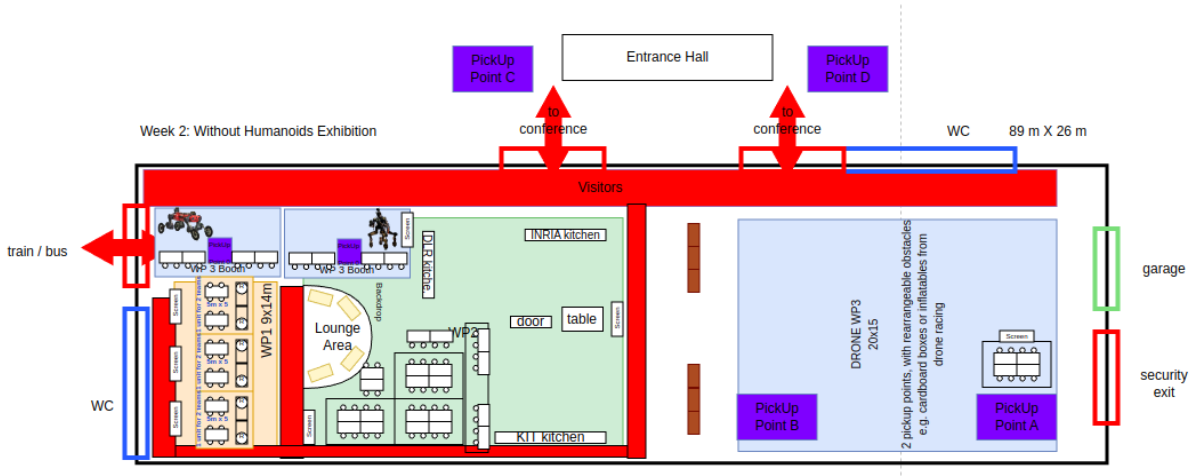


Figure 2.8: Nancy Congress Center Coopetition space allocation.

Chapter 3

Qualification Procedure & Coopetition Timeline

This section outlines the registration and qualification procedures for the Industrial Robots League, the Service Robots League, and the Outdoor Robots League. Additionally, it provides an overview of the timeline for the euRobin Coopetition 2024, scheduled to be held in Nancy.

3.1 EuroCore Registration

The teams will be able to share modules and resources through the EuroCore platform. This is an ongoing effort and the registration in this platform is still to be announced.

3.2 Registration and Qualification

The registration and qualification process for any of the leagues (Industrial Robots, Service Robots, Outdoor Robots) requires the submission of the following material:

1. A team description paper that must show the importance of the team's participation in the coopetition. The paper should highlight the team's key achievements and results, current research lines, applicability to real-world scenarios, and how these relate to the league's topics. Additionally, teams must specify which algorithms they intend to share via the euROBIN EuroCore platform and provide descriptions of the software modules they require. The paper should include the league name (Industrial Robots, Service Robots, Outdoor Robots), the team's name, the team members' names, contact information, website details, a description of the robot's hardware, and relevant photos.
2. A video showcasing one or multiple robots executing a task related to the league where the team intends to participate. For instance, in a manipulation task for the Industrial Robots League, a human-robot interaction task for the Service Robots League, or a navigation with obstacle avoidance task for the Outdoor Robots League. The task goal must be clear and the robot execution must clearly achieve it. The video can be sped up and must have a maximum duration of 10 minutes. The team must state if the execution is fully autonomous or has some degree of tele-operation.

Both the team description paper and video must be submitted by the deadline defined in Figure 3.1, to the following email address eurobin-coopetition@dlr.de.

Following the submission of qualification materials, teams will undergo a selection evaluation based on the quality, maturity, and relevance of the research described. The selected teams will be announced on the qualification announcement date, as defined in Figure 3.1.

After receiving the qualification email, teams have 5 days to confirm their participation in the coopetition. In the Industrial Robots League, the qualified teams will receive a taskboard immediately after confirming their participation.

3.3 Timeline

Figure 3.1 illustrates the timeline for the euRobin Coopetition 2024.

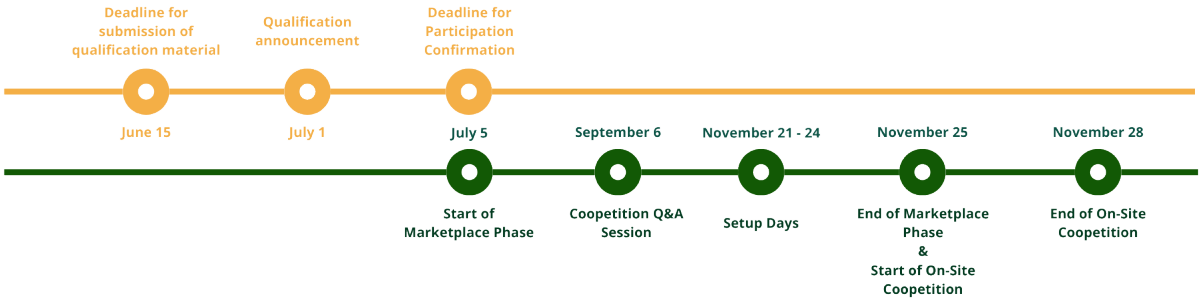


Figure 3.1: Nancy Coopetition Timeline.

Chapter 4

Industrial Robots League

The Industrial Robots League is a competition in robotic manipulation with a new industry-supported benchmark using an internet-connected electronic task board, as depicted in Figure 4.1. A battery powered microcontroller on each task board tracks the users interactions with the device and automatically reports individual task execution times to a public web dashboard and EuroCore.

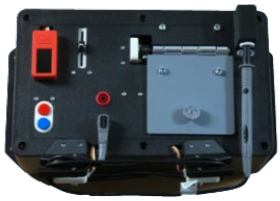


Figure 4.1: Internet-connected electronic task board.

The Industrial Robots League competition unfolds in two distinct phases as illustrated in Figure 4.2. Initially, teams apply to receive the task board by mail, solving it in their robot lab, and submitting their solutions after a 4-week development period. Subsequently, in the second phase, the top-performing teams are invited to present their solutions in person at the On-Site Coopetition. During this phase, teams showcase their task board solution and they further extend their solutions to manipulate objects provided by both the organizers and other participating teams in the Bring Your Own Device (BYOD) Challenge. The Industrial Robots League ends with the Robot Skill Bazar as described in Section 2.3.3.

The sections that follow introduce the arena, the assessed functionalities, and the rules for the Industrial Robots League.

4.1 Arena

The Industrial Robots League arena accommodates six dedicated robot platform work areas, totaling approximately 124m^2, as illustrated in Figure 4.3. The Coopetition organization will provide teams with individually marked-off workspaces featuring equipment storage, power connections, and internet cable connection.

Screens displaying teams progress tracked by the EuroCore and the web dashboard will also be available.

Figure 2.8 depicts the allocation of venue space for the Industrial Robots League.

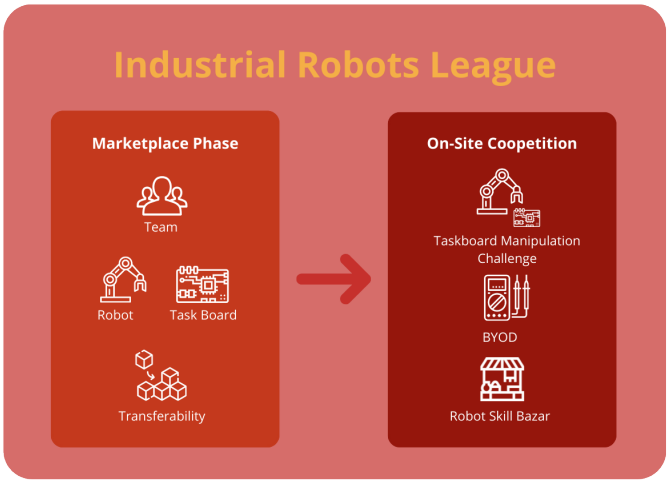


Figure 4.2: Industrial Robots League structure with the Marketplace Phase and the On-Site Coopetition.

4.2 Functionalities

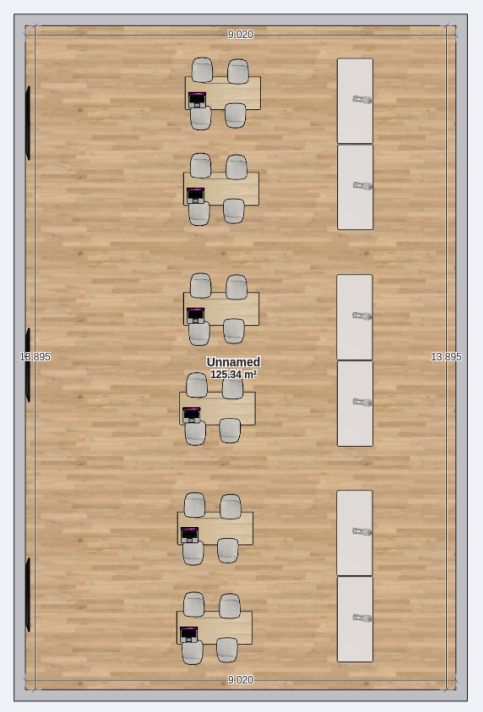
The manipulation skills and capabilities under examination in the competition are listed in the table 4.1.

Skill Category	Description
Object Localization	Robot must detect the location of the task board and press a button.
Interactive Manipulation	Robot must read a randomly generated setpoint value from a screen and move a slider to match.
Insertion	Robot must pick up the Probe Plug and insert it into the Test Port.
Levering	Robot must open the hinged door, pick up the Probe and insert it into the terminal block.
Wrapping	Robot must wrap the cable of the Probe around two posts and insert the Probe back into its holder.
Pressing	Robot must press a button to end the trial.

Table 4.1: The manipulation skills and capabilities under examination in the competition.

4.3 Rules

This section focuses on the On-site Coopetition. On this stage, teams will start by performing a live demo of their task board purposed solution in the Taskboard Manipulation Challenge, and then will be asked to demonstrate their robot skill transferability in the BYOD Challenge. At the end, every team must showcase their robot skills and software pipelines in the Robot Skill Bazar.



(a)

(b)

Figure 4.3: Arena layout for the Industrial Robots League, encompassing around 126m^2. It includes six designated work areas for teams and their robot platforms.

The following sections describe the Taskboard Manipulation and BYOD challenges in detail.

4.3.1 Taskboard Manipulation Challenge

Description

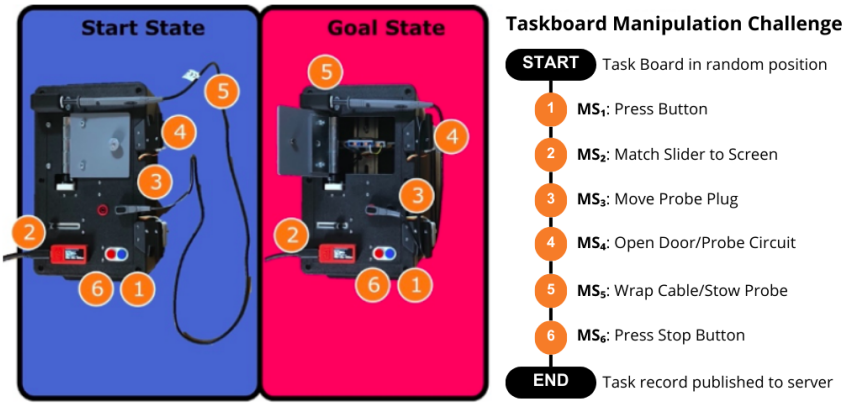


Figure 4.4: An electronic competition task board is depicted in both its initial and final states. The competition entails a trial protocol for robot teams to autonomously accomplish tasks within a 10-minute time limit.

Participants need to come up with a real-world automated solution for the competition task board, which is randomly placed on a worktable. Team robot platforms follow a trial protocol: first, they find the task board, and then they do a sequence of actions that mimic checking out an industrial electronics cabinet, all within a set time. Figures 4.4 and 4.5 depict the trial protocol teams must follow.

A microcontroller on each task board handles the timing and task completion automatically, and the results from each run are shown on the EuroCore and on a public web dashboard. Teams get points for completing milestones successfully, as tracked by the performance circuits on the task board.

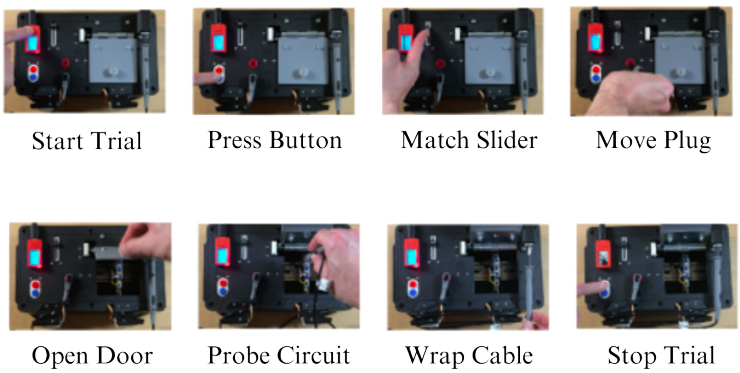


Figure 4.5: Industrial Robots League task demonstrated by a human user.

Pre-Start Setup

- The task board is picked up and placed in the competition area by the judge to randomize its position.
- Removable elements are placed in their starting nest positions.

Starting Condition

- Operator presses the start button on the board to start the trial clock.

End Condition

- The robot manipulator presses the stop button.
- When the trial clock reaches the maximum time of 10 minutes or the judges stops the trial.

Scorecard

- Tasks are segmented into milestones, each evaluated separately. The total task score is the sum of all milestone scores.
- The final score of a milestone can vary based on its condition level, which represents the varying degrees of complexity associated with the milestone.
- Each milestone will be evaluated by the taskboard and the information will be transmitted to both EuroCore and the web dashboard.
- Referees have the authority to rectify any incorrect assessments made by the taskboard directly within EuroCore.
- Referees are empowered to impose penalties for any shortcomings observed during the execution of each milestone.
- Milestone execution will also be evaluated by non-technical referees, including the audience.

Task Scoring

Milestone	b_m
MS₁: Localize Board	
Press blue button	
MS₂: Move Plug	
Pick up probe plug	
Insert probe plug	
MS₃: Adjust Slider	
Reach SP1 center	
Reach SP2 on screen	
MS₄: Probe Inner Circuit	
Open door	
Insert probe and close circuit	
MS₅: Stow Probe Cable	
Trigger post sensor	
Insert probe tip into holder	
MS₆: Finnish Task	
Press stop button	

Total Score (excluding special penalties & standard bonuses) *0*

Condition Level

Milestone	l_m
Manipulation	
The robot requires human assistance	*0.0*
The robot is teleoperated	*0.0*
The team attaches a custom handle to the taskboard to accommodate their specific gripper	*0.0*
The robot manipulator is fully autonomous and the taskboard is left unchanged	*1*

Penalties

Milestone	p_m
Manipulation	
The robot collides with the taskboard, table or any other object present in the environment	

4.3.2 BYOD Challenge

The Bring-Your-Own-Device (BYOD) Challenge allows teams to demonstrate their robot skill transferability as illustrated in Figure 4.6. Teams must adapt the Taskboard Manipulation Challenge illustrated in Section 4.3.1 to probe battery circuit on an real electrical device using a different multimeter.

Teams are encouraged to bring their own BYODs and they will be presenting their final solution to an expert jury who will be awarding points depending on the quality of the demonstration.

Pre-Start Setup

- Teams must show their BYOD to the referees to be approved.

Starting Condition

- The referee places the BYOD in a random position within the competition table.

End Condition

- When the trial clock reaches the maximum time of 10 minutes or the judges stops the demonstration.

Scorecard

- The judge and referees will observe the demo and will award up to X tokens.

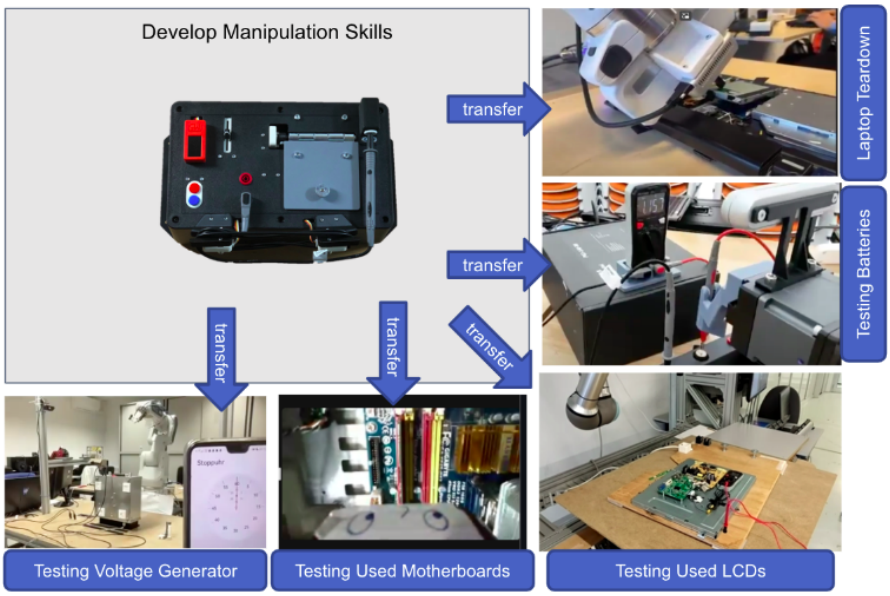


Figure 4.6: Examples of manipulation skill transferability demonstrations from the task board to real world applications.

4.3.3 Robot Skill Bazaar

After completing the Taskboard Manipulation Challenge, teams will showcase their robot skills in an Open Challenge format, promoting their capabilities through EuroCore in the Robot Skill Bazaar Challenge.

For more details on the organization of this challenge, please see Section 2.3.3.

Chapter 5

Service Robots League

The Service Robots League presents a challenge aimed at advancing the capabilities of service and assistive robots, particularly in the scope of personal and domestic applications.

After the Marketplace Phase, during which teams can engage in transferability activities outlined in Section 2, teams will transition to the main challenge of the Coopetition, the Multi-Functional Service Robot Challenge as depicted in Figure 5.1. The league culminates with the Robot Skill Bazaar challenge, as described in Section 2.3.3.

The following sections introduce the arena, the evaluated functionalities, and the regulations regarding the Service Robots League.

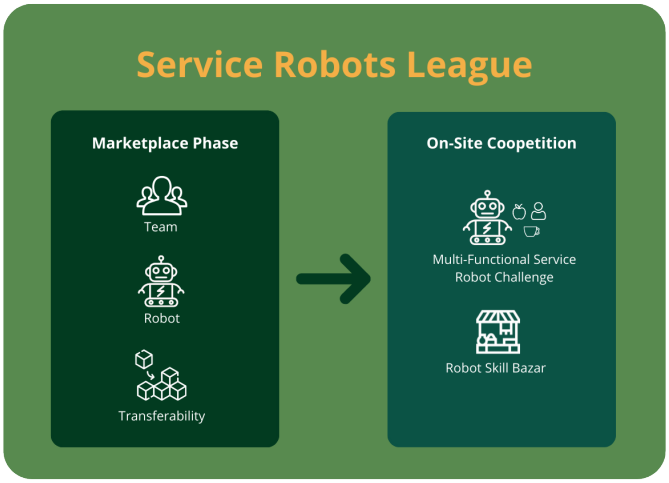


Figure 5.1: Service Robots League structure with the Marketplace Phase and the On-Site Coopetition.

5.1 Arena

The Service Robots League arena encompasses three distinct kitchen environments spanning approximately 280m^2 in total. This infrastructure is made possible through collaboration with three euRobin project partners: the German Aerospace Center (DLR), Karlsruhe Institute of Technology (KIT), and Research Center INRIA. Within the arena, one of the kitchens will be separated by a door, and a shared table will be positioned at the center, serving all three kitchens. Additionally, a screen will be installed to display teams progress as tracked by EuroCore, along with other pertinent information.

For the convenience of participating teams, the Coopetition organization will provide individually designated workspaces equipped with storage facilities, power connections, and internet cable access.

Figure 2.8 depicts the allocation of venue space for the Service Robots League.

5.2 Functionalities

The robotic skills and capabilities under examination in the Service Robots League are listed in the table 5.1

Skill Category	Description
Speech Recognition	The robot must be able to understand instructions given by the referees.
Environment Navigation	The robot must successfully navigate in the area whilst avoiding obstacles.
Object and People Detection	The robot must detect objects and people in the environment.
Object Feature Recognition	The robot must identify specific features or characteristics of objects within an image or scene.
Object Manipulation	The robot must be able to grasp object present in the environment and place it in a desired surface.
Task Planning	The robot must set a plan of execution given an arbitrary command.

Table 5.1: The robotic skills and capabilities under examination in the competition.

5.3 Rules

In the Service Robot League, teams are challenged with the Multi-Functional Service Robot and the Robot Skill Bazaar challenges.

The following section describes the Multi-Functional Service Robot Challenge in detail.

5.3.1 Multi-Functional Service Robot Challenge

Description

The Multi-Functional Robot Challenge presents teams with tasks of varying difficulty and conditional levels. Two possible scenarios are offered to teams, outlined in Figure 5.2. Robots will start by retrieving an object from a designated location within one kitchen and subsequently delivering it to a different location or handing it to an individual located elsewhere.

The task-related details, including designated places, actions, kitchens, locations, and objects, are dynamically provided by a command generator at runtime under the guidance of the referee. These details adhere to a predetermined set of elements, as exemplified in Table 5.2.

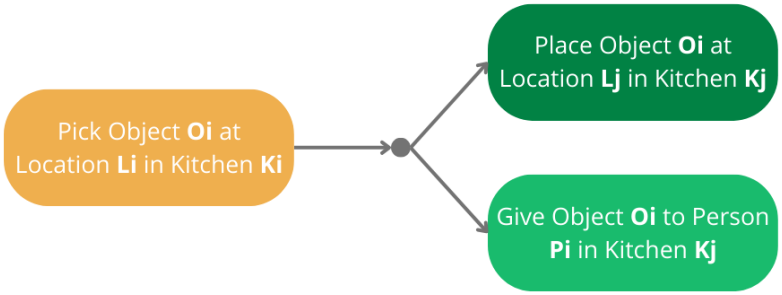


Figure 5.2: Multi-Functional Robot Challenge.

Kitchen (K_i)
DLR
KIT
INRIA

Location (L_i)
Dishwasher
Table
Cabinet

Object (O_i)
YCB Objects
KIT Dataset

Table 5.2: The Multi-Functional Robot Challenge information constraints.

Teams have the option to mitigate task unpredictability by specifying preferred actions, kitchens, locations, and objects that align with their robotic platform. However, any such restrictions will incur penalties imposed by the referees.

The challenge comprises three tasks, each with escalating difficulty levels:

1. Teams execute pick-and-place/give actions within the designated **base** kitchen
2. Teams execute pick actions within the **base** kitchen and perform place/give actions in an undisclosed kitchen
3. Teams execute pick-and-place/give actions in an undisclosed kitchens.

The term **base** kitchen refers to a kitchen where teams feel most proficient and comfortable operating, which they must select during the setup days. Teams are required to inform the referees of their chosen base kitchen prior to task execution.

Teams are granted three attempts per difficulty level to complete the assigned tasks.

Pre-Start Setup

- The referee utilizes the command generator to generate the tasks and ensures that the arena fulfills all conditions necessary for task execution
- The teams inform the referee of any tasks constraints or preferences

Starting Condition

- The robot is somewhere placed in the arena

End Condition

- The robot executes the place or give task successfully.

- When the task clock reaches the maximum time of 10 minutes or the judges stops the task clock.

Scorecard

- Tasks are segmented into milestones, each evaluated separately. The total task score is the sum of all milestone scores.
- The final score of a milestone can vary based on its condition level, which represents the varying degrees of complexity associated with the milestone.
- Each milestone will be evaluated by the referees and the information will be transmitted to the EuroCore.
- Referees are empowered to impose penalties for any shortcomings observed during the execution of each milestone.
- Milestone execution will also be evaluated by non-technical referees, including the audience.

Task Scoring

Milestone	b_m
MS₁: Navigation	
The robot navigates to the Instruction Point	
MS₂: Command Understanding	
The robot understands the given instruction (the robot needs to reproduce the command using speech or written logs)	
MS₃: Navigation	
The robot navigates to Location L_i in Kitchen K_i	
MS₄: Manipulation	
The robot opens the door on his way to Kitchen K_i (if required)	
MS₅: Manipulation	
The robot opens the drawer/cabinet at Location L_i in Kitchen K_i (if required)	
MS₆: Object Detection	
The robot detects the Object O_i at Location L_i in Kitchen K_i	
MS₇: Object Manipulation	
The robot picks the Object O_i at Location L_i in Kitchen K_i	
MS₈: Navigation	
The robot navigates to Location L_j in Kitchen K_j	
MS₉: Manipulation	
The robot opens the door on his way to Kitchen K_j (if required)	
MS₁₀: Object Manipulation	
The robot places the Object O_i at Location L_j in Kitchen K_j	
The robot gives the Object O_i to Person P_i in Kitchen K_j	

Total Score (excluding special penalties & standard bonuses) *0*

Condition Level

Milestone	l_m
Navigation	
The robot is teleoperated	*0.0*
The robot uses artificial landmarks (i.e. aruco markers or april tags) to localize	*0.0*
The robot is fully autonomous. No teleoperation or artificial landmarks	*1*
Speech Understanding	
The team runs script, i.e. bypass natural language understanding and speech-to-text	*0.0*
The command is given by command line or any other interface, i.e. bypass speech-to-text	*0.0*
The robot understands the command via speech	*1*
Manipulation	
The robot requires human assistance	*0.0*
The robot is teleoperated	*0.0*
The team attaches a custom handle to the object to accommodate their specific gripper	*0.0*
A standard unmodified handle is used for object manipulation	*1*
Object Detection	
Known Objects	
Only the target object is initially placed in Location L_i	*0.0*
Several different objects are in Location L_i without any occlusions from the robot's POV	*0.0*
Several different objects are in Location L_i, and the target object to be picked up is either hidden behind another object or at least only partially visible	*0.0*
Unknown Objects	
Only the target object O_i is initially placed in Location L_i	*0.0*
Several different objects are in Location L_i without any occlusions from the robot's POV	*0.0*
Several different objects are in Location L_i, and the target object to be picked up is either hidden behind another object or at least only partially visible	*1*

Penalties

Milestone	p_m
Navigation	
The robot hits obstacles	
Speech Understanding	
The robot misinterprets the given instruction	
Manipulation	
The robot collides with objects present in the environment	
The robot picks the wrong object	
Object Detection	
The robot misdetects the object	
Task Configuration	
The team specifies task topology: place or give action	
The team specifies Object O_i	
The team specifies pick Location L_i	
The team specifies place/give Location L_j	
Task Execution	
The robot picks different Object O_i	
The robot performs pick in different Location L_i	
The robot performs place/give in different Location L_j	

5.3.2 Robot Skill Bazaar

After completing the Multi-Functional Service Robot Challenge, teams will showcase their robot skills in an Open Challenge format, promoting their capabilities through EuroCore in the Robot Skill Bazaar Challenge.

For more details on the organization of this challenge, please see Section 2.3.3.

Chapter 6

Outdoor Robots League

The Outdoor Robots League presents a challenge aimed at enhancing the capabilities of autonomous delivery robots, encompassing both aerial and ground-based platforms.

Following the Marketplace Phase, where teams can participate in transferability activities detailed in Section 2, teams will progress to the primary challenge of the Coopetition: the Delivery Robot Challenge. The league concludes with the Robot Skill Bazaar challenge, as outlined in Section 2.3.3. Figure 6.1 illustrates the Outdoor Robots League overall structure.

Subsequent sections will introduce the arena, discuss evaluated functionalities, and outline regulations pertaining to the Outdoor Robots League.

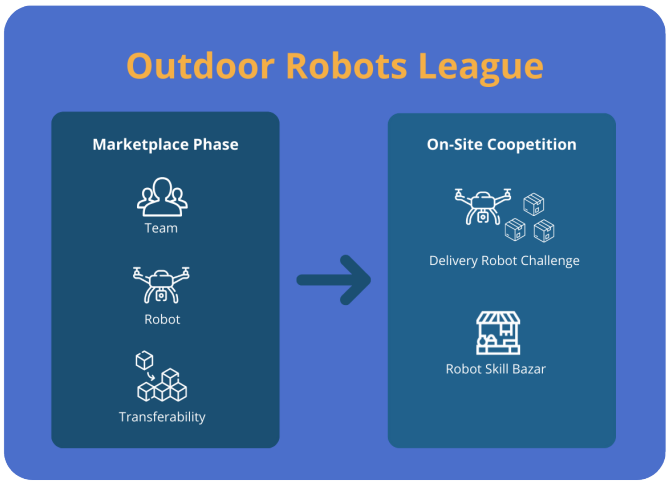


Figure 6.1: Outdoor Robots League structure with the Marketplace Phase and the On-Site Coopetition.

6.1 Arena

The Outdoor Robots League arena will be tailored to accommodate different types of robots. Aerial robots will have a designated arena covering approximately 560m^2, as depicted in Figure 2.8. To ensure participant and visitor safety, the arena will be encircled by a safety net. Additionally, the arena will feature adjustable obstacles, such as cardboard boxes or inflatables used in drone racing, made possible through collaboration with the University of Seville (USE) and other project partners. Two Pick-Up/Delivery points will also be incorporated into the drone arena for task execution.

Ground robots, on the other hand, will navigate throughout the entire venue, including the entrance hall and the exterior space leading to Place de la Republique. Several Pick-Up/Delivery Points will be strategically positioned in these areas to facilitate the Delivery Robot Challenge. In-venue obstacles such as stairs, ramps, and doors will be utilized, along with traffic cones and obstacles from the Humanoids Challenge, such as cross-fit boxes, to provide additional challenges.

To support participating teams, the Coopetition organization will furnish individual workspaces equipped with storage facilities, power connections, and internet access. Furthermore, a screen will be installed to display teams progress as tracked by EuroCore, alongside other pertinent information.

6.2 Functionalities

The robotic skills and capabilities under examination in the Outdoors Robots League are listed in the table 6.1

Skill Category	Description
Speech Recognition	The robot must be able to understand instructions given by the referees.
Environment Navigation	The robot must successfully navigate in the area whilst avoiding obstacles.
Object and People Detection	The robot must detect objects and people in the environment.
Object Feature Recognition	The robot must identify specific features or characteristics of objects within an image or scene.
Object Manipulation	The robot must be able to grasp object present in the environment and place it in a desired surface.
Task Planning	The robot must set a plan of execution given an arbitrary command.

Table 6.1: The robotic skills and capabilities under examination in the Outdoors Robots League

6.3 Rules

In the Outdoors Robot League, teams are challenged with the Delivery Robot and the Robot Skill Bazaar challenges.

The following section describes the Delivery Robot Challenge in detail.

6.3.1 Delivery Robot Challenge

The Delivery Robot Challenge offers tasks of varying difficulty and conditional levels, presenting teams with two possible scenarios depicted in Figure 6.2. Robots start by retrieving a parcel from a designated Pick-Up point and then delivering it to a designated Delivery Point or handing it to an individual.

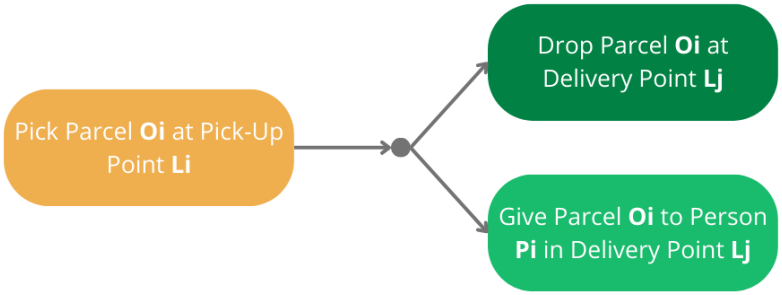


Figure 6.2: Delivery Robot Challenge.

Task-related details, including designated actions, Pick-Up and Delivery points, and parcel, are dynamically provided by a command generator at runtime under the guidance of the referee. These details adhere to a predetermined set of elements, as demonstrated in Table 6.2.

Pick-Up/Delivery Point (L_i)
L_1
L_2
L_3
L_4
L_5

Object (O_i)
Parcel with Aruco Tag A_1
Parcel with Aruco Tag A_2
Parcel with Aruco Tag A_3
Parcel with Aruco Tag A_4
Parcel with Aruco Tag A_5

Table 6.2: The Delivery Robot Challenge information constraints.

Teams have the option to mitigate task unpredictability by specifying preferred actions, Pick-Up and Delivery points, and parcel that align with their robotic platform. However, any such restrictions will incur penalties imposed by the referees.

The Delivery Robot Challenge comprises three tasks, each with escalating difficulty levels:

1. For ground robots:
   1.1. Easy-level route within the venue
   1.2. Medium-level route from the venue to the entrance hall
   1.3. Hard-level route from the venue to the outside
2. For aerial robots:
   2.1. Easy-level route with no obstacles
   2.2. Medium-level route includes small to medium-sized obstacles
   2.3. Hard-level route includes large obstacles and narrow passages.

Teams are granted three attempts per difficulty level to complete the assigned tasks.

Pre-Start Setup

- The referee utilizes the command generator to generate the tasks and ensures that the arena fulfills all conditions necessary for task execution
- The teams inform the referee of any tasks constraints or preferences

Starting Condition

- The robot is somewhere placed in the arena

End Condition

- The robot executes the place or give task successfully.
- When the task clock reaches the maximum time of 10 minutes or the judges stops the task clock.

Scorecard

- Tasks are segmented into milestones, each evaluated separately. The total task score is the sum of all milestone scores.
- The final score of a milestone can vary based on its condition level, which represents the varying degrees of complexity associated with the milestone.
- Each milestone will be evaluated by the referees and the information will be transmitted to the EuroCore.
- Referees are empowered to impose penalties for any shortcomings observed during the execution of each milestone.
- Milestone execution will also be evaluated by non-technical referees, including the audience.

Task Scoring

Milestone	b_m
MS₁: Navigation	
The robot navigates to the Instruction Point	
MS₂: Command Understanding	
The robot understands the given instruction (the robot needs to reproduce the command using speech or written logs)	
MS₃: Navigation	
The robot navigates to Pick-Up Point L_i to retrieve Parcel O_i	
MS₄: Manipulation	
The robot opens the door on his way to Pick-Up Point L_i (if required)	
MS₅: Object Detection	
The robot detects the Parcel O_i at Pick-Up Point L_i	
MS₆: Object Manipulation	
The robot picks the Parcel O_i from Pick-Up Point L_i	
MS₇: Navigation	
The robot navigates to Delivery Point L_j	
MS₈: Manipulation	
The robot opens the door on his way to Delivery Point L_j (if required)	
MS₉: Object Manipulation	
The robot drops the Parcel O_i at Delivery Point L_j	
The robot gives the Parcel O_i to Person P_i in Delivery Point L_j	

Total Score (excluding special penalties & standard bonuses) *0*

Condition Level

Milestone	l_m
Navigation	
The robot is teleoperated	*0.0*
The robot uses artificial landmarks (i.e. aruco markers or april tags) to localize	*0.0*
The robot is fully autonomous. No teleoperation or artificial landmarks	*1*
Speech Understanding	
The team runs script, i.e. bypass natural language understanding and speech-to-text	*0.0*
The command is given by command line or any other interface, i.e. bypass speech-to-text	*0.0*
The robot understands the command via speech	*1*
parcel	
Manipulation	
The robot requires human assistance	*0.0*
The robot is teleoperated	*0.0*
The team attaches a custom handle to the object to accommodate their specific gripper	*0.0*
A standard unmodified handle is used for object manipulation	*1*
Object Detection	
Only the target Parcel O_i is initially placed in Pick-Up Point L_i	*0.0*
Several different Parcels are in Pick-Up Point L_i without any occlusions from the robot POV	*1*

Penalties

Milestone	p_m
Navigation	
The robot hits obstacles	
Speech Understanding	
The robot misinterprets the given instruction	
Manipulation	
The robot collides with objects present in the environment	
The robot picks the wrong parcel	
Object Detection	
The robot misdetects the parcel	
Task Configuration	
The team specifies task topology: place or given action	
The team specifies Parcel O_i	
The team specifies Pick-Up Point L_i	
The team specifies Delivery Point L_j	
Task Execution	
The team picks different Parcel O_i	
The team performs pick in different Pick-Up Point L_i	
The team performs place/give in different Delivery Point L_j	

6.3.2 Robot Skill Bazaar

After completing the Delivery Robot Challenge, teams will showcase their robot skills in an Open Challenge format, promoting their capabilities through EuroCore in the Robot Skill Bazaar Challenge.

For more details on the organization of this challenge, please see Section 2.3.3.