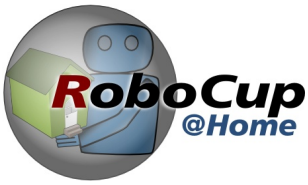

RoboCup@Home

Rules & Regulations

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About this Rulebook

This is the official rulebook of the @Home competition 2020. It has been written by the 2020 *Technical Committee* (TC).

How to Cite this Rulebook

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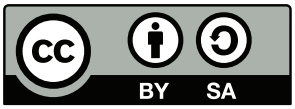


Contents

Chapter 1

Introduction

1.1 RoboCup

RoboCup is an international joint project to promote AI, robotics, and related fields. It is an attempt to foster AI and intelligent robotics research by providing standard problems where a wide range of technologies can be integrated and examined. More information can be found at: http://www.robocup.org/.

1.2 RoboCup@Home

The @Home league aims to develop service and assistive robot technology with high relevance for future personal domestic applications. It is the largest international annual competition for autonomous service robots and is part of the RoboCup initiative. A set of benchmark tests is used to evaluate the robots' abilities and performance in a realistic non-standardized home environment setting. Focus lies on the following domains but is not limited to: *Human-Robot Interaction* and Cooperation, *Navigation* and *Mapping* in dynamic environments, *Computer Vision* and *Object Recognition* under natural lighting conditions, Object *Manipulation*, *Adaptive Behaviors*, *Behavior Integration*, *Ambient Intelligence*, Standardization and *System Integration*. It is collocated with the RoboCup symposium.

1.3 Organization

@Home is organized into three subcommittees. Current members are listed at: https://athome.robocup.org/committees/.

Executive Committee The *Executive Committee* (EC) consists of members of the board of trustees and representatives of each activity area.

Technical Committee The *Technical Committee* (TC) is responsible for the rules of the league. Main focus is writing the rulebook and refereeing. Members of the *Executive Committee* (EC) are always members of the *Technical Committee* (TC) as well.

Organizing Committee The *Organizing Committee* (OC) is responsible for the organization of the competition. They create the schedule and provide information about the scenario. The *Local Organizing Committee* (LOC) is responsible for the set up and organization of the venue.

1.4 Infrastructure

RoboCup@Home Mailing List The official @Home mailing list can be reached at: robocup-athome@lists.robocup.org. You can subscribe to the mailing list at: http://lists.robocup.org/cgi-bin/mailman/listinfo/robocup-athome

RoboCup@Home Web Page The official @Home website that also hosts this rulebook can be found at: https://athome.robocup.org/

RoboCup@Home Rulebook Repository The official @Home *Rulebook Repository* is where rules are publicly discussed before applying changes. The entire @Home community is welcome and encouraged to actively participate in creating and discussing the rules. The *Rulebook Repository* can be reached at: https://github.com/RoboCupAtHome/RuleBook/

RoboCup@Home Telegram Group The official @Home *Telegram Group* is a communication channel for the @Home community where rules are discussed, announcements are made, and questions are answered. Beyond supporting the technical aspects of the competition, the group is a meeting point to stay in contact with the community, foster knowledge exchange, and strengthen relationships. The *Telegram Group* can be reached at: https://t.me/RoboCupAtHome

RoboCup@Home Wiki The official @Home *Wiki* is meant to be a central place to collect information on all topics related to the @Homeleague. It was set up to simplify and unify the exchange of relevant information. This includes but is certainly not limited to hardware, software, media, data, and more. The *Wiki* can be reached at: https://github.com/RoboCupAtHome/AtHomeCommunityWiki/wiki

1.5 Leagues

@Home is divided in three leagues. Two are *Standard Platform Leagues* (SPL) where each team uses the same robot platform and an *Open Platform League* (OPL) where teams are free to choose their robot. The official leagues and their names are:

- *Domestic Standard Platform League* (DSPL)
- *Social Standard Platform League* (SSPL)
- *Open Platform League* (OPL)

All leagues share the same set of rules. The *Domestic Standard Platform League* (DSPL) uses the *Toyota HSR* platform shown in figure 1.1 and the *Social Standard Platform League* (SSPL) uses the *Softbank Pepper* platform shown in figure 1.2.

Figure 1.1: Toyota HSR

Figure 1.2: Softbank / Aldebaran Pepper

1.6 Competition

The competition consists of two *Stages* and the *Finals*. Each stage comprises a series of *Tests*. The best teams from *Stage I* advance to *Stage II* with more difficult tests. The competition ends with the *Finals* where the two highest ranked teams of each league compete to win.

1.7 Awards

All the awards need to be approved by the *RoboCup Federation* (RCF). Not all awards must be given.

Winner of the Competition Each league has 1st, 2nd, and 3rd place award trophies. If eight or fewer teams are participating, no 3rd place award trophy is given.

Note: For the following awards, the *Executive Committee* (EC) nominates a set of candidates from which the *Technical Committee* (TC) elects the winner. One cannot nominate or vote for their own team.

Best Human-Robot Interface Award To honour outstanding Human-Robot Interfaces, the *Best Human-Robot Interface Award* may be given to one of the participating teams. It is especially important that the interface is open and available to the @Home community.

Best Poster To foster scientific knowledge exchange and reward a teams' effort to present their contributions, all scientific posters of each league are eligible to receive the *Best DSPL Poster Award*, *Best SSPL Poster Award*, or *Best OPL Poster Award*, respectively.

Posters are graded on presenting innovative and state-of-the-art research within a field with direct application to RoboCup@Home in an appealing, easy-to-read way while demonstrating successful and clear results. In addition to be attractive and well-rated in the *Poster Session* (see 4.2), the explained research must have impact in the team's performance during the competition.

Note: For the following award, the *Technical Committee* (TC) and team leaders nominate a set of candidates from which the *Executive Committee* (EC) elects the winner. One cannot nominate or vote for their own team.

Open-Source Software Award For promoting software exchange and collaboration, RoboCup@Home awards the best open source software contributions to the community. The software must be easy to read, properly documented, follow standard design patterns, be actively maintained, and meet IEEE software engineering metrics of scalability, portability, maintainability, fault tolerance, and robustness. In addition, the open sourced software must be made available as a framework-independent standalone library so it can be reused with any software architecture.

Candidates must send their application to the *Technical Committee* (TC) at least one month before the competition in form of a short paper (max 4 pages) following the same format used for the *Team Description Paper* (TDP) (see Section 3.1.1). The paper should include a brief explanation of the approach, comparison with State-of-the-Art techniques, statement of the used metrics and software design patterns, and the name of the teams and other collaborators that are also using the software.

Open Challenge Award To encourage teams to present their research to the rest of the league, @Home grants the *Best Open Challenge Award* to the best open demonstration presented during the competition. This award is granted only if a team has demonstrated innovative research that is related to the global objectives of @Home.

Skill Certificates The @Home league features certificates for the robots best at a the skills below:

- Navigation
- Manipulation
- Speech Recognition

- Person Recognition

A team is given the certificate if it scored at least 75% of the attainable points for that skill. This is counted over all tests and challenges, so e.g. if the robot scores manipulation points during the Storing Groceries test, that will count towards the Best in Manipulation certificate. The certificate will only be handed out if the team is *not* the overall winner of the competition.

Chapter 2

Concepts Behind the Competition

A set of key concepts apply to every RoboCup@Home competition and the performed tests.

Autonomy All robots participating in the RoboCup@Home competition have to be *autonomous*. This means no human is allowed to remote control the robot during a test. Furthermore, a test must not be solved using *Open Loop Control*.

Applicability The tests should reward useful, robust, general, cost effective, and applicable solutions. The tests should increase in difficulty and complexity each year.

Lean set of rules To allow for different, general and transmissible approaches in the RoboCup@Home competitions, the rule set should be as lean as possible. Still, to avoid rule discussions during the competition itself, it should be very concrete leaving no room for diverse interpretation.

Social Relevance The tests should show socially relevant results. The aim is to convince the public about the usefulness of autonomous robot applications in domestic settings by directly assisting and helping humans.

Scientific Value The tests should allow teams to show novel approaches with high scientific value.

Time Constraints Setup and test time is limited to allow for many participating teams and to emphasize the competition aspect of @Home.

Non Standard Scenario In order to reward robust and general solutions, RoboCup@Home has no standard scenario. It should resemble a typical domestic setting of the host country. Furthermore, tests may take place outside of the scenario, i.e., in an previously unknown environment like, for example, a nearby public space.

Appeal The competition should appeal to the audience and the public. Therefore high attractiveness and originality of an approach should be rewarded.

Community Although teams compete against each other, the members of the @Home league are expected to cooperate and exchange knowledge to advance technology together. Every team is encouraged to share relevant technical, scientific, and team related information through the *Team Description Paper* (TDP) and by participating in the various communication channels (see 1.4).

Chapter 3

General Rules & Regulations

These are the general rules and regulations for the competition in the RoboCup@Home league. They apply to every test unless a test description differs, in which case it overrides the general rule.

3.1 Team Registration and Qualification

In order to participate, a team must answer the *Call for Participation* (CFP) announced on the @Home mailing list by sending in their *Application*. Then, they need to be selected in the *Qualification* phase and finally, complete their *Registration*.

3.1.1 Application

An application consists of a *Team Video*, *Team Website*, and *Team Description Paper* (TDP).

Team Video The *Team Video* should show that the team has a running robot platform that is able to, at least partly, solve the tests in the last rulebook. Therefore, the video should focus on abilities required in *Stage I* and also include some skills required in *Stage II*. The video should be self-explanatory and designed for a general audience. Any editing, e.g. speed up, needs to be indicated. The video should not exceed 10 min and needs to be publicly uploaded.

Team Website The *Team Website* should be designed for a broad audience. Therefore, it should include scientific material, but also interesting media. The default language of the website needs to be English.

Team Description Paper The *Team Description Paper* (TDP) is describing the team's main research, including the scientific contributions, goals, scope, and results, as well as, describing the used hardware. It needs to be in English, up to eight pages long, and formatted according to the guidelines of the RoboCup Symposium. An addendum as the 9th page (after references) needs to include:

- Team Name
- Contact Information
- Website Url
- Team Member Names
- Photo(s) of the Robot(s) (unless included previously)
- List of External Devices (see 3.5)
- List of 3rd Party Software

3.1.2 Qualification

The *Organizing Committee* (OC) will select teams for *Qualification*. The selections will mainly be based on:

- The content on the *Team Website*, focusing on publications and open source resources
- Number and complexity of abilities shown in the *Team Video*
- Scientific value, novelty and contributions in the *Team Description Paper* (TDP)

Secondary evaluation criteria are:

- Performance in previous competitions
- Previous contributions to the @Home community

3.1.3 Registration

Qualified teams can register at the RoboCup@Home competition. In order to max out the number of participants, qualified teams *must* contact the *Organizing Committee* (OC) to confirm (or cancel) participation.

Confirming implies that the team has sufficient resources to complete *Registration* and attend the competition. Teams that fail to confirm their participation will be disqualified.

3.2 Audience Interaction

Only some tests require direct interaction with the audience. In order to make all tests more appealing (see 2) and engaging, informing the audience about what is happening is important.

3.2.1 Visualization

All scenarios will have a screen, visible to the audience, that the teams can use to display, e.g., a robot's state, world model, and current plan. An example of such a visualization is the *VizBox* by Loy van Beek (`https://github.com/LoyVanBeek/vizbox`). Using and enhancing the capabilities of the *VizBox* or developing another open source visualization is greatly appreciated and considered a contribution to the RoboCup@Home community.

3.3 Scenario

Most tests take place in the RoboCup@Home *Arena*. Some tests can take place outside, in a previously unknown public place (see 2). This section describes the *Arena* and how it is furnished, as well as, known information that is shared in all tests.

3.3.1 RoboCup@Home Arena

The RoboCup@Home *Arena* is a realistic home setting consisting of inter-connected rooms. The minimal configuration consists of:

- Bedroom
- Dining Room

- Living Room
- Kitchen

There is one *Arena* for each league and an additional one for setup and training shared by all leagues.

An *Arena* is decorated and dressed to resemble a typical apartment in the hosting country, including all necessities and decorations one can find in a normal house.

3.3.2 Walls, Doors and Floor

The indoor home setting will be surrounded by high and low walls built up using standard fair construction material.

- **Walls:** Walls have a minimum height of 60 cm. A maximum height is not specified, but the audience must be able to watch the competition.
- **Doors:** There will be at least two doors, leading in and out of the arena. Inside the arena, rooms are connected by doors (at least one). All doors have handles, not knobs. Doors can be closed during tests, robots are expected to open them or plan around.
- **Floor:** The floor and doorways of the arena are even. There will be no significant steps or even stairways. Minor unevenness such as carpets, transitions in floor covering between different areas, and minor gaps (especially at doorways) can be expected.
- **Appearance:** Floor and walls are mainly uni-colored but can contain texture, e.g., a carpet on the floor, a poster or picture on the wall.

3.3.3 Furniture

The arena will be furnished with items common in the host country.

The minimal configuration consists of:

- Bed,
- Couch
- Small Table
- Small Dinner Table with Two Chairs
- Two Trash Bins
- Television with Remote Control
- Cupboard with Drawers
- Bookcase
- Coat Rack

The *Arena's* kitchen must have:

- Dishwasher
- Sink
- Powered Refrigerator (with some cans and plastic bottles inside).

A typical arena setup is shown in Figure 3.1a.

(a) Typical arena **(b)** Typical objects

Figure 3.1: Example RoboCup@Home scenario.

Cupboard

The cupboard can be any shelf-like furniture in which objects can be placed. At least one shelf must be lower than 90 cm.

Fridge

Fridge must not be smaller than 120 cm. At least one powered and functioning fridge is required.

3.3.4 Objects

Some tests involve recognizing and manipulating objects (See Figure 3.1b). The *Technical Committee* (TC) will compile a list of at least 30 objects at the competition. This list contains a picture of the object, as well as, its official name and *Object Category*. Every *Object Category* has an assigned *Predefined Location* (see 3.3.6) where objects of that category can usually be found during tests. Each object is provided at the competition for training.

There are two types of objects:

1. ***Known Objects*:** Objects previously known by the robot, split into:
   1.1. ***Consistent Objects*:** Objects that always look the same.
   1.2. ***Similar Objects*:** Objects that look different to the provided image but are still considered the same by people (e.g. differently colored apple, cloth with different pattern).
   1.3. ***Standard Objects*:** Objects chosen from the *YCB Dataset*[1]. They are published 6 months in advance on the RoboCup@Home website[2] so that they can be aquired and trained beforehand.
2. ***Unknown Objects*:** Any other object that is not in the object list but can be grasped or handled (e.g. arena decorations).

Known objects include at least:

[1] http://www.ycbbenchmarks.com/object-set/
[2] https://athome.robocup.org/standard-objects

- ***Tableware*:** Dish, bowl, cup, and napkin (See Figure 3.2b).
- ***Cutlery*:** Fork, knife, and spoon.
- ***Trash Bags*:** Big plastic trashbags, preferrably with handle.
- ***Bags*:** Lightweight. With stiff, vertical handles (See Figure 3.2a).
- ***Trays*:** Tray or basket, intended for two-handed manipulation (See Figure 3.2c).
- ***Pourable*:** An object whose content can be poured (e.g. jug).
- ***Heavy Object*:** Weight between 1.0kg and 1.5kg (e.g. water bottle).
- ***Tiny Object*:** A lightweight object, no bigger than 5cm (e.g. teabag).
- ***Fragile Object*:** An easy-to-break object (e.g. egg).
- ***Deformable Object*:** A flexible object that may appear in different shapes (e.g. cloth).

(a) Brightly colored paper bags **(b)** Cereal bowls **(c)** Serving tray

Figure 3.2: Example of objects

During the competition, objects can be requested based on their *Object Category*, physical attributes, or a combination of both. Relevant attributes to be used are:

- Color (e.g. red, blue, black with white dots, etc.).
- Relative estimated size (smallest, largest, big one, etc.).
- Relative estimated weight (lightest, heaviest).
- Relative position (left of, right most, etc.).
- Object description (is fragile, is container, can be poured, requires two hands, etc.).

Remark: Measurements are estimations and based on common sense. It is OK for robots to consider similar objects to be about the same size or weight. Don't bring a scale.

3.3.5 Changes to the Arena

Since the robots should be able to function in the real world, the *Arena* is not fixed and might change without further notice.

1. **Major Changes:** Any furniture (*Predefined Location* or not) might be moved slightly between tests. It will not change rooms or move drastically inside a room. However, a couch or table may be rotated, moved to its side etc. Walls will stay in place and rooms will not change function. Passages might be blocked.
2. **Minor Changes:** Slightly moved chairs, slightly closed doors, or anything similar cannot be avoided and might happen at any time, even during a test.

Only during *Setup Days* (see 4), teams can make changes to the arena if something severely hinders the robots (e.g. high door steps). These changes must be agreed upon by all team leaders and in accordance with the *Technical Committee* (TC) on location.

During *Setup Days* and in between tests, teams can take objects from the *Arena* for training. A team may not take more than five objects at once and for longer than an hour. Teams may not modify any of the objects. At least half an hour before a test slot, all items must be returned to the *Arena*.

3.3.6 Predefined Rooms and Locations

Some tests involve a *Predefined Location*.

- **Rooms:** Each room has a function (e.g. kitchen, bed room).
- **Furniture:** Some furniture will be named and sorted into a location class (e.g. couch and arm chair are both in the seating class).
- **Doors:** Two doors leading in and out of the *Arena* will be named entrance and exit respectively.

3.3.7 Predefined Names

Some tests involve memorizing a person's name. All people in the arena have an assigned *Predefined Name* chosen from a list compiled by the *Technical Committee* (TC). This list has 20 names of which 25 % are male, 25 % female, and 50 % gender-neutral, taken from the list of most common used names in the United States.

3.3.8 Wireless Network

For wireless communication, an *Arena Network* is provided. The actual infrastructure depends on the *Local Organizing Committee* (LOC). Reliability and stability is not guaranteed. Robots are expected to run regardless.

The following rules apply:

- Only the *Arena Network* can be used by robots during tests.
- Only the active team in a test is allowed to use the *Arena Network*.
- One Virtual Local Area Networks (VLANs) is provided per team.
- Each VLAN is most likely to have its own SSID/password.
- VLAN traffic is separated from any other team, routed to the team's network cable in the team area.
- Each VLAN is also connected to the Internet.

Teams broadcasting unauthorized (aka rogue) wireless networks will be disqualified from the competition, and have their devices confiscated by the OC. This includes smartphones and concealed SSIDs. It is advised to verify your devices.

Note: All information about the scenario will be announced during *Setup Days* (see 4).

3.4 Robots

3.4.1 Number of Robots

- **Registration:** The maximum number of robots used in tests per team is *two* (2).
- **Regular Tests:** Only one robot is allowed per test run. For different test runs, different robots can be used.
- **Open Demonstrations:** In the *Finals* both robots can be used simultaneously.

3.4.2 Appearance and Safety

Robots should have a product-like appearance and be safe to operate. The following rules apply to all robots:

- **Cover:** The robot's internal hardware (electronics and cables) should be covered in an appealing way. The use of (visible) duct tape is strictly prohibited.
- **Loose cables:** Loose cables hanging out of the robot are not permitted.
- **Safety:** The robot must not have sharp edges or elements that might harm people.
- **Annoyance:** The robot must not be continuously making loud noises or use blinding lights.
- **Marks:** The robot may not exhibit any kind of artificial marks or patterns.
- **Driving:** To be safe, the robots should be careful when driving. Obstacle avoidance is mandatory.

3.4.3 Standard Platform Leagues

For Robots competing in a *Standard Platform League* (SPL), modifications and alterations to the robots are strictly forbidden. This includes, but is not limited to, attaching, connecting, plugging, gluing, and taping components into and onto the robot, as well as, modifying or altering the robot structure. Not complying with this rule, leads to an immediate disqualification and penalization of the team (see 3.9).

Robots are allowed to "wear" clothes, have stickers (e.g., a sticker exhibiting the logo of a sponsor), and be painted as long as they are compliant with section 3.4.2.

DSPL Modifications

In the *Domestic Standard Platform League* (DSPL), some modifications to the *Toyota HSR* are allowed. An official *Mounting Bracket* is provided by Toyota for the *Toyota HSR*. Any laptop fitting inside the *Mounting Bracket* can be used as additional on board computing. Furthermore, teams are allowed to attach the following devices to the robot or the laptop in the *Mounting Bracket*:

1. **Audio:** USB audio output device, e.g. USB-powered speaker, possibly with sound card.
2. **Wi-Fi Adapter:** USB-powered IEEE 802.11ac (or newer) compliant device.
3. **Ethernet Switch:** USB-powered IEEE 802.3ab (or newer) compliant device.

A maximum of three such devices can be attached, they cannot increase the robot's dimension.

3.4.4 Open Platform League

Robots competing in the *Open Platform League* (OPL) must comply with security specifications in order to avoid causing any harm while operating.

Size and Weight

- **Dimensions:** The dimensions of a robot should not exceed the limits of an average door (200 cm by 70 cm). The *Technical Committee* (TC) may allow the qualification and registration of larger robots, but it cannot be guaranteed that the robots can actually enter the arena. In doubt, contact the *Local Organizing Committee* (LOC).
- **Weight:** There is no specific weight restriction. However, the weight of the robot and the pressure it exerts on the floor should not exceed local regulations for the construction of buildings which are used for living and/or offices in the country where the competition is being held.
- **Transportation:** Team members are responsible for quickly moving the robot out of the *Arena*. If the robot cannot move by itself (for any reason), the team members must be able to transport the robot away in an easy and fast manner.

Emergency Stop Button

- **Accessibility and Visibility:** Every robot has to provide an easily accessible and visible *Emergency Stop* button.
- **Color:** It must be coloured red and be the only red button on the robot. The TC may ask the team to tape over or remove any other red button present on the robot.
- **Robot behavior:** When the *Emergency Stop* button is pressed, the robot and all its parts must stop moving immediately.

Note: All robot requirements will be tested during *Robot Inspection* (see 4.3).

3.5 External Devices

Everything a team uses in a test that is not part of the robot is considered an *External Device*. An *External Device* must be authorized by the *Technical Committee* (TC) during *Robot Inspection* (see 4.3). The TC decides whether an *External Device* can be used freely or under referee supervision and determines its impact on scoring. Wireless devices, such as hand microphones and headsets, are not allowed with the exception of *External Computing*.

3.5.1 On-Site External Computing

Computing resources that are not physically attached to the robot are considered *External Computing*. They must be placed in the *External Computing Resource Area* (ECRA), which is announced by the *Technical Committee* (TC) during *Setup Days* (see 4), where a switch, connected to the *Arena Network* (see 3.3.8), will be available. During a *Test Block* (see 3.6.2), only two persons are allowed in the ECRA at any time, one team member each of the two teams up next. No peripherals (e.g. screens, mouses, keyboards) are allowed to be present. Laptops can only be placed if the team is up next and need to be removed as soon as the test finishes.

During a *Test Slot*, all people must stay at least 1 m away from the ECRA. Interacting with anything in the ECRA after the referee has given the start signal will cause the test to end with a score of zero.

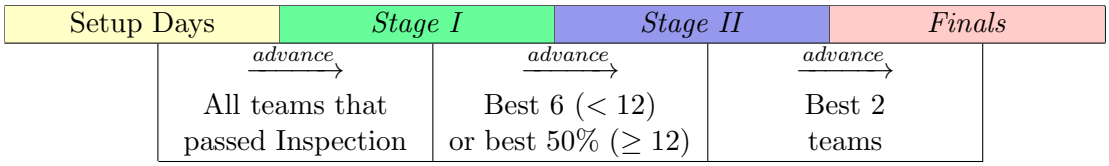
3.5.2 On-Line External Computing

Teams can utilize *External Computing* through the internet connection of the *Arena Network* (e.g. cloud services, online APIs). These must be announced to and approved by the *Technical Committee* (TC) one month prior to the competition.

3.6 Competition Procedure

A RoboCup@Home competition consists of the following stages:

1. ***Robot Inspection*:** For security, robots are inspected during *Setup Days*. All registered teams can participate.
2. ***Stage I*:** First set of tests, assessing the robot's basic abilities. Only teams that passed the *Robot Inspection* can participate.
3. ***Stage II*:** Second set of tests, assessing more complex abilities and behaviors. The best 50 % of teams[3] (after *Stage I*) can participate.
4. ***Finals*:** An open demonstration, asking teams to showcase complex behaviors and novel approaches. The two best scoring teams (*Stage I* and *Stage II* combined) can participate.



In case of having no considerable score deviation between a team advancing to the next stage and a team dropping out, the *Technical Committee* (TC) may announce additional teams advancing to the next stage.

3.6.1 Scenarios

The tests in *Stage I* and *Stage II* are divided in two thematic scenarios:

- ***Housekeeper*:** Features tests related to cleaning, organizing, and maintenance.
- ***Party Host*:** Focuses on providing general assistance during a party by attending the needs of the guests.

[3] If the total number of teams is less than 12, up to 6 teams may advance to *Stage II*

3.6.2 Schedule

There are two *Test Blocks* in a competition day. Each block has a stage and one or two thematic scenarios assigned. An exception is the *Restaurant* test (see 6.3) which has its own block. During a block, each team has at least two *Test Slots* available, where they can choose which test, fitting the stage and scenario, they want to perform. The teams must inform the *Organizing Committee* (OC) which tests they will perform a day prior, usually in the *Team Leader Meeting* (see 3.6.3). Teams have to indicate to the OC when they are skipping a *Test Slot*. Without such indication, they may receive a penalty (see 3.9.1).

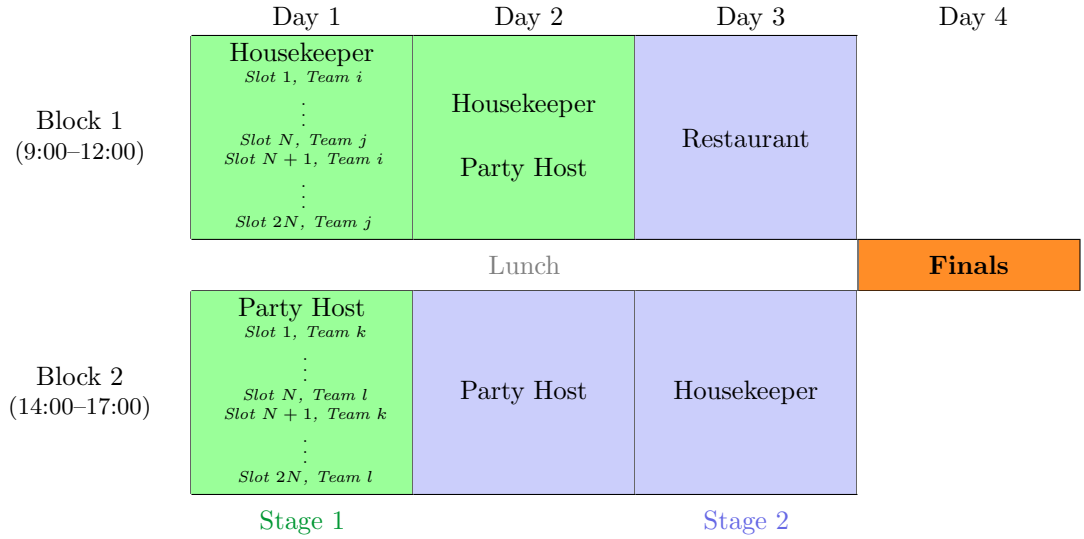


Table 3.1: Example schedule. Each of the N teams has two slots assigned per block. At least two blocks are scheduled per day with assigned themes.

Note: The schedule will be announced during *Setup Days* (see 4) by the OC.

3.6.3 Team Leader Meeting

In the evening before each competition day, a *Team Leader Meeting* is held. Attendance from all teams participating in the next day's tests is mandatory. During the meeting, teams can ask questions and discuss the upcoming tests with the TC and OC. The starting time will be announced by the OC. Decisions made in the TLM are binding. The TC and referees on site will decide on anything coming up during or after a test.

3.6.4 Scoring System

Each test has a main objective and a set of bonuses. To score in a test, a team must accomplish the main goal (in parts if allowed). Bonuses are only given if at least 50 % of the points for the main goal are achieved. Overall scoring in a stage is calculated as the sum of the maximum score obtained in each test. The final score is calculated differently and is normalized (see 7.4). A team cannot get a negative score for a test unless a penalty was received.

Note: Once a scoresheet has been signed by the team leader or the scores have been published, the TC decision is irrevocable.

3.7 Test Procedure

3.7.1 Safety First!

Robots need to be safe when interacting with people and their environment.

- **Emergency Stop:** At any time, when operating the robot inside and outside the scenario, a team member has to stop the robot immediately if there is a remote possibility of dangerous behavior towards people and/or objects.
- **Stopping on Request:** If a referee, member of the TC, OC, or EC, or trustee of the federation tells the team to stop the robot, there will be no discussion and the robot has to be stopped *immediately*.

Collisions

- **Slightly Touching:** Slightly touching objects is tolerated but unadvised.
- **Major Collisions:** If a robot crashes into something during a test, the robot is stopped immediately.
- **Functional Touching:** Robots are allowed to apply pressure to objects, push away furniture, and interact with the environment in general. However, the robot must clearly announce any collision-like interaction. Referees can still immediately stop a robot in case or suspicion of dangerous behavior.
- **Robot-Robot Avoidance:** If two robots encounter each other, they both have to actively try to avoid the other robot.
  1. A robot which is not going for a different route within a reasonable amount of time (30 s) is removed.
  2. A non-moving robot blocking the path of another robot for longer than a reasonable amount of time (30 s) is removed.

3.7.2 Arena Access

- **Setup Days:** During *Setup Days*, the number of team members inside the *Arena* is not limited.
- **Before Test Block:** 30 min before a *Test Block*, no team members are allowed inside the *Arena*.
- **Tests:** During a *Test Slot*, the maximum number of team members allowed inside the *Arena* is *one* (1) (*Volunteers* excluded).
- **Final Demonstrations:** During the *Finals*, the number of team members inside the *Arena* is not limited.

3.7.3 Fair Play

Fair play and cooperative behavior is expected from all teams during the entire competition.

- **Evaluating:** Evaluate other teams' performances fairly, especially as jury member.
- **Refereeing:** Apply all rules equally to all teams.
- **Volunteering:** Interact reasonably with other teams' robots and as instructed.

This especially means:

- **No Cheating:** Faking autonomous robot behavior and similar is highly punished.
- **No Rule Exploitation:** Do not exploit rules in ways that are obviously not intended. If you find an exploitable rule, inform the *Technical Committee* (TC) *before* the competition.
- **Hidden Modifications:** Modifying robots is against the basis of the *Standard Platform Leagues* (SPL) and therefore, highly punished.

3.7.4 Robot Autonomy

Robots acting autonomously is among the key concepts of @Home (see 2).

- **No Touching:** During a test, team members are not allowed to make contact with their robot. Contact by referees and volunteers is only allowed if it is in a *natural* way and required by the task.
- **Natural Interaction:** The default way to interact with a robot are gestures and speech.
- **No Remote Control:** Remotely controlling a robot is strictly prohibited. This also includes pressing buttons or influencing sensors on purpose.

Note: Disregard of the aforementioned rules can lead to penalties and disqualifications for a test, the competition, and future competitions.

3.7.5 Expected Robot Behavior

Unless stated otherwise, it is expected that the robot always behaves and reacts in the same way a polite and friendly human being would. A robot should always announce and describe what it is doing or planning to do.

3.7.6 Removal of Robots

Robots not obeying the rules are stopped and removed from the arena. It is the decision of the referees and the TC members monitoring the test if and when to remove a robot. When told to do so, the team has to immediately stop the robot and remove it from the arena without disturbing the ongoing test.

3.7.7 Start Signal

The default signal to start a test is opening the entrance door (see 3.3.6). Other start signals are allowed but must be authorized by the TC during *Robot Inspection* (see 4.3).

1. **Door Opening:** The robot is waiting behind the door, outside the arena and accompanied by a team member. The test starts when a referee opens the door.
2. **Start Button:** If the robot is not able to automatically start after the door is open, the team may start the robot using a *Start Button*.

2.1. The procedure must be *very* easy to execute.
2.2. It is allowed to use the robot's contact/pressure sensors (e.g. pushing the head or an arm joint).

3. **Alternative Start Signal:** Other means of starting the robot are allowed.
   - QR codes
   - Verbal instructions
   - Custom HRI interfaces (apps, software, etc.)

Note: Using a start signal other than the default one, may be penalized in some tests.

3.7.8 Referees

All tests are monitored by at least two *Referees*, ideally members of the TC, OC, or EC. At least one has to be a member of the TC and acting main referee.

3.7.9 Volunteers

Some tests require *Volunteers* to take part in a test and interact with the robot. Teams are asked to send members as volunteers for the duration of a *Test Block*. Larger teams are asked more frequently.

- **Announcement:** *Referees* will ask teams to select *Volunteers* at least 30 min before a *Test Block*.
- **Instruction:** Before each block, *Referees* will instruct the *Volunteers*.

3.7.10 Moderators

The LOC is responsible for organizing test moderation in the local language. The OC may request the participating teams to provide a team member for moderation. Candidates have to be fluent in the moderation language (default is English).

- **No Interference:** The moderator has to avoid to interfere with the test. Therefore, they must follow the instructions of the *Referees*.
- **Explanation:** Explain the test and the robot's plan.
- **Commentary:** Comment on the robot's performance.

Note: Not showing up on time for volunteering or moderation will result in a penalty (see 3.9).

3.7.11 Operators

Unless stated otherwise, robots are operated by a *Referee* or a *Volunteer*. If the robot fails to understand the default operator, the team may request to select their own *Custom Operator*. Penalty may apply when using a *Custom Operator*.

3.7.12 Time Limits

In accordance with 2, each test has a defined time limit.

- **Inactivity:** If the robot is stuck or not progressing the task, the robot is considered inactive and the main *Referee* can decide to end the test.

- **Requesting Time:** If the robot is doing time-consuming calculations or planning and only appears inactive, the robot has to announce what it is doing and for how long.
- **Setup Time:** Unless stated otherwise, there is no extra setup time. 60 s after the previous team has left the arena, the robot must be ready to enter.
- **Time's Up:** When the time is up, the team has to immediately remove the robot from the arena. No more additional score will be given.
- **Show Must Go On:** In special cases, the *Referee* may let the robot continue the test for demonstration purposes. No additional points will be scored.

3.7.13 Restart

Some tasks allow a single restart, a procedure in which the team is allowed to quickly fix any issue with the robot. Restarts can be requested only when the test permits it, and when the amount of remaining time is greater than 50% of the total. The procedure is as follows:

1. The team request a restart.
2. The robot is taken to the initial position (e.g. outside the arena) and gets fixed.
3. When the robot is ready, the team informs the referee.

The following rules apply:

1. **Number of Restarts:** When allowed, the maximum number of restarts is one (1).
2. **Early Request:** Restart is **NOT** allowed after the first 50% of the alloted time has elapsed.
3. **Time:** The timer is neither restarted nor stopped.
4. **One-Minute Setup** The team has 1 minute to fix the robot counting when the referee announces th restart. If the robot is not ready, the test is considered finished.
5. **Scoring:** If the score of the second attempt is lower than the score of the first one, the average score of first and second run is taken.

3.8 Deus ex Machina

To allow teams to participate in tests, where the robot is only missing one ability to complete the main goal, and to allow robots to continue in case of minor malfunctions, a robot can request human assistance during a test, called *Deus ex Machina* (DEM). Help can not be requested to complete bonus goals.

3.8.1 Procedure

To request human assistance while solving a task:

1. **Request Help:** The robot has to indicate loud and clear that it requires human assistance. It must clearly state:
   1.1. The nature of the assistance
   1.2. The particular goal or desired result
   1.3. How the action must be carried out (when necessary)

1.4. Details about how to interact with the robot (when necessary)

2. **Supervise:** The robot must be aware of the human's actions, being able to tell when the requested action has been completed, as well as guiding the human assistant (if necessary) during the process.
3. **Acknowledge:** The robot must politely thank the human for the assistance provided.

3.8.2 Scoring

The amount of times a robot can request human assistance is not limited, but score reduction applies each time. The score for a goal or partial goal cannot be negative due to DEM reductions. Possible DEM requests are stated for each test with the corresponding score reductions. Other requests must be announced one day before the test in the *Team Leader Meeting* where the TC will decide on the scoring. In general, points will be deducted increasingly for:

1. **Partial Solutions:** The robot requests a partial solution (e.g. pointing to the person the robot is looking for or placing an object within grasping distance).
2. **Full Awareness:** The robot requests a whole step of the test to be completed but is able to track and supervise activity. This means detecting when something goes wrong and when the request is done.
3. **No Awareness:** The robot requests a whole step of the test to be completed and has to be told when the request is done.

3.8.3 Bypassing Speech Recognition

When the robot is not able to receive spoken commands, teams are allowed to provide alternatives.

1. **Custom Operator:** A reduction of 20% of the maximum attainable score is applied when a *Custom Operator* is requested. The person choosen by the team gives the command *exactly* as instructed by the referee.
2. **Gestures:** A reduction of 20% of the maximum attainable score is applied when a gesture (or set of gestures) is used to instruct the robot.
3. **QR Codes:** A reduction of 30% of the maximum attainable score is applied when a QR code is used to instruct the robot.
4. **Alternative Input Method:** A reduction of up to 30% of the maximum attainable score is applied when an alternative HRI interface is used to instruct the robot.

Alternative HRI Interfaces

Alternative methods and interfaces for HRI offer a way for a robot to start or complete a task. Any reasonable method may be used, with the following criteria:

- **Intuitive:** A manual should not be needed. Teams are not allowed to explain how to interact with the robot.
- **Effortless:** Must be as easy to use as uttering a command.
- **Smart:** The interface adapts to the user input, displaying only the options that make sense or that the robot can actually perform.

Award: The best interface is awarded the Best Human-Robot Interface award (see 1.7). **Note:** All methods to bypass ASR need to be announced during *Robot Inspection* (see 4.3).

3.9 Special Penalties

3.9.1 Missing Test Slot

1. **Announcement:** If a team cannot participate in a test (for any reason), the team leader has to announce this to the OC at least 30 min before the *Test Block*.
2. **Penalties:** If a team is not present at the start position when their *Test Slot* starts, the team is not allowed to participate in the test anymore. If no announcement was made, the team gets a penalty of *250 points*.

3.9.2 Extraordinary Penalties

1. **Cheating:** If a team member is found breaking the fair play rules (see 3.7.3), the team will be automatically disqualified of the running test, and a penalty of *500 points* is handed out.
2. **Faking:** If a team starts a test, but it does not solve any of the partial tasks (and is obviously not trying to do so), a penalty of *250 points* is handed out. The decision is made by the referees and the monitoring TC member.
3. **Collisions:** In case of major, negligent collisions the team will be automatically disqualified of the running test, and a penalty of *500 points* is handed out.
4. **Volunteer Attendance:** If a *Volunteer* is not at the arena on time, the team receives a penalty of *250 points*.
5. **Jury Attendance:** Jury members missing a performance to evaluate are excluded from the jury, and the team is disqualified from the test.
6. **Modifying Standard Platform Robots:** If any unauthorized modification is found on a *Standard Platform League* (SPL) robot, the responsible team will be immediately disqualified for the entire competition while also receiving a penalty of *500 points* in the overall score.

Note: Receiving these penalties might negatively influence future qualification decisions.

3.10 Open Challenge

On the first two competition days after the regular test blocks ended, there will be an opportunity for teams to present an open challenge in which teams can demonstrate their novel research and approaches.

3.10.1 Procedure

1. **Participation:** Teams have to announce whether they want to perform an open challenge to the OC during *Setup Days*.
2. **Time:** Each team gets a 10 minute time slot of which 8 minutes are for presenting and 2 minutes for questions by the audience.

3. **Arena Changes:** The team can rearrange the arena when their time slot starts but all changes need to be reverted as soon as their time slot ends.
4. **Focus:** While the demonstrations are intended to share research insights, we still want to see robots performing. Do not turn the open challenge into an academic lecture.
5. **Leagues:** Ideally, all @Home leagues' open challenges will be scheduled consecutively, to give the opportunity to watch all open challenges. In case there are more than 12 participants across leagues, each league will hold their open challenge concurrently.
6. **Award:** Participating teams are eligible to receive the *Best Open Challenge Award* (see 1.7).

Chapter 4

Setup Days

The first days at a RoboCup@Home competition before the tests start are the *Setup Days*. This time is used by teams to assemble and test their robots and adjust to the local scenario. To foster knowledge exchange between teams, a *Poster Session* is held. To ensure safety and compliance with the rules, a *Robot Inspection* is conducted.

4.1 General Setup

Depending on the overall RoboCup schedule, the *Setup Days* last for one or two days.

- **Start:** They start when the venue opens for the first time.
- **Intention:** Teams setup their team area and robots.
- **Tables:** The LOC will setup and randomly assign team tables.
- **Arena:** The *Arenas* are available to all teams of the respective league. The OC may schedule special test or mapping slots in which arena access is limited. Note, that furnishing may not be complete yet.
- **Objects:** The delegation of EC, TC, OC and LOC will buy the objects (see 3.3.4). Note, that the objects may not be available at all times and not from the beginning.

4.2 Poster Session

The *Poster Session* is for teams to present their research to the @Home community. Before the session a *Welcome Reception* is held. The time before and after the *Poster Session* is for teams to exchange knowledge and to get to know each other.

- **Time:** The *Poster Session* is held in the evening of the last setup day.
- **Place:** It takes place in the *Arena* and/or in the team area.
- **Welcome Reception:** Time for teams to gather for the *Poster Session*. Snacks and beverages (beers, sodas, etc.) are served.
- **Organization:** It is the responsibility of the OC and the LOC to organize catering and location. This includes:
  - Poster stands for each team or alternatives to present the posters.
  - Snacks and drinks.
  - Inviting officials, sponsors, LOC, and *RoboCup Federation* (RCF) trustees to the event.
- **Poster Presentation:** Each team gives a short presentation of their poster.

- **Discussion:** Afterwards, teams are free to look at the posters, ask questions and discuss the presentations.

Poster Presentation

- **Time:** Each team has a maximum of three minutes to give a short presentation of their poster.
- **Evaluation:** The posters are evaluated by a jury consisting of one member (preferable the team leader) of each team. The evaluation should be based on the presentation, as well as, any questions and discussions.
- **Criteria:** For each of the following evaluation criteria, a maximum of 10 points is given per jury member:
  - Novelty and scientific contribution.
  - Relevance for RoboCup@Home.
  - Presentation (Quality of poster, presentation style, and discussion).
- **Score:** The points given by each jury member are scaled to obtain a maximum of 50 points. The total score for each team is the mean of the jury member scores. To neglect outliers, the N best and worst scores are left out. The points are added to a team's *Stage I* score:

$$score = \frac{\sum \text{team-leader-score}}{\text{number-of-teams} - (2N+1)}, N = \begin{cases} 1, & \text{number-of-teams} \geq 10 \\ 2, & \text{number-of-teams} < 10 \end{cases}$$

- **Sheet collection:** Evaluation sheets are collected by the *Organizing Committee* (OC) at an announced time.

4.3 Robot Inspection

Passing the *Robot Inspection* is necessary for a robot to participate in any test.

- **Schedule:** The *Robot Inspection* is held during the last day of the *Setup Days*. A team order is announced by the *Organizing Committee* (OC) beforehand.
- **Procedure:** The inspection starts, like a regular test, with the opening of the entrance door. The robot needs to enter the *Arena* and drive to a designated inspection point. On command (team's choice) the robot leaves through the exit door.
- **Inspectors:** The robots are inspected by the *Technical Committee* (TC).
- **Checked aspects:** It is checked if the robots comply with the rules (see 3), checking in particular:
  - Emergency button(s).
  - Collision avoidance. An inspector steps in front of the robot.
  - Voice of the robot. It must be loud and clear.
  - Custom containers (bowl, tray, etc.).
  - External devices.
  - Alternative Human-Robot interfaces.
  - ***Standard Platform Robots***

    - Neat appearance.
    - No banned modifications have been made.
    - DSPL modifications.
  - ***Open Platform robots***
    - Robot speed and dimension.
    - Start button.
    - Other safety issues (duct tape, hanging cables, sharp edges etc.).

- **Re-Inspection:** If the robot is not approved, it is the responsibility of the team to get the approval later. This means, retrying directly after the regular *Robot Inspection* schedule or asking the TC to be inspected at a later time.
- **Time Limit:** No strict time limit is given since approval of external devices can take time. But, inactive robots and robots moving too slowly or not towards the inspection point are removed quickly.
- **Accompanying Team Member:** Each robot is accompanied by only one team member (team leader is advised).
- **OC instructions (at least 2h before the Robot Inspection):**
  - Announce the entry and exit doors.
  - Announce the location of the inspection point.

Chapter 5

Tests in Stage I

Housekeeper

Party Host

5.1 General Purpose Service Robot

The robot can be asked to do anything involving abilities required in *Stage I* of this rulebook.
Focus: *System Integration*.

Main Goal

Execute 3 commands requested by the operator.
Reward: 750pts (250 points per command)

Bonus Rewards

1. Understand a command given by naive operator (50pts, each)
2. Complete all 3 commands in time (100pts)

Setup and Procedure

1. **Location:** The test mostly takes place inside the arena (some commands might require the robot to go outside).
2. **Instruction Point:** An instruction point is assigned inside the arena where the robot has to go to receive a command.
3. **Operators:** A *professional* operator (i.e. the referee) gives the commands. Optionally, teams can choose to receive commands by a *naive* operator who has no background in robotics, i.e., an audience member. The team can decide to use a *Custom Operator* outright or after the robot fails to understand the professional or naive operator.
4. **Command Generator:** Commands will be generated using the official *GPSR Command Generator* available 2 months prior to the competition in the official repository[1].

Additional Rules and Remarks

1. **Not Going to Instruction Point:** If the robot requests commands from somewhere else than the instruction point, a score reduction of 50 pts is applied.
2. **Partial Scoring:** The main task allows partial (per command) scoring.
3. **Deus ex Machina:** Score reduction applies per given command as follows:
   - **Custom Operator:** Choosing a custom operator to understand a command causes a score reduction of 50pts.
   - **Alternative HRI:** Using an alternative HRI to understand a command causes a score reduction of 75pts.
   - **Further Assistance:** Helping a robot accomplish a task causes a score reduction in line with 3.8.2 and other *Stage I* tests.

[1] https://github.com/kyordhel/GPSRCmdGen

Referee Instructions

- Provide the commands to the operators.
- Make sure the *Arena* is in normal condition.

OC Instructions

2 hours before the test

- Generate commands.
- Announce the location of the instruction point.
- Recruit volunteers to assist during the test.

Score Sheet

The maximum time for this test is 5 minutes.

Action	Score
Main Goal	
Complete a command	*3×250*
Receiving command not from the instruction point	*3×–50*
Custom Operator	*3×–50*
Alternative HRI	*3×–75*
Bonus Rewards	
Understand command given by naive operator	*3×50*
Complete all 3 commands in time	*100*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Using alternative start signal (see sec. 3.7.7)	*–100*
Total Score (excluding penalties and standard bonuses)	*1000*

5.2 Storing Groceries

The robot stores groceries into a pantry shelf while adhering to how objects are arranged in it, e.g., storing an apple next to other fruits.
Focus: *System Integration*, *Manipulation*, *Computer Vision*, *Object Recognition*.

Main Goal

Move 5 objects from a table into a shelf, grouping them by category.
Reward: 500pts (100pts per object)

Bonus Rewards

1. Opening the shelf door (100pts)
2. Moving a *tiny* object (200pts)
3. Moving a *heavy* object (200pts)

Setup and Procedure

1. **Location:** The testing area has a shelf and a table nearby.
2. **Shelf:** The shelf contains objects arranged in groups either by category or likeliness.
3. **Shelf Door:** The shelf door is open by default. The team leader can request the door to be closed and score additional points for opening it. If the robot fails to open the door, it must clearly state it and request the referee to open it.
4. **Objects:** Some of the objects are placed behind the door and cannot be accessed unless the door is open.
5. **Heavy and Tiny Objects:** Objects used in this test are lightweight and average-sized. The team leader can, however, request a tiny and a heavy object to be used and score additional points for picking them.
6. **Table** The table's rough location will be announced beforehand, having its position either left, right, or behind the robot.

Additional Rules and Remarks

1. **Misplacing Objects:** Placing an object at the wrong place in the shelf causes a score reduction of 40pts.
2. **Partial Scoring:** The main task allows partial (per object) scoring.
3. **Deus ex Machina:** Score reduction for requesting human assistance is applied per object as follows:
   - **Request Object Locations by Gesture:** Pointing out where to place an object causes a reduction of 20pts.
     Request Object Interaction by a Human: Having a human pick up or place an object causes a reduction of 60pts.

Referee Instructions

The referee needs to

- Place objects in the shelf, grouping them by likeliness.
- Place 5–10 objects on the table.
- Ask teams whether they want the shelf door opened.
- Ask teams whether they want a heavy or tiny object.

OC Instructions

2 hours before the test

- Announce which table and shelf will be used in the test.
- Announce a rough location for the table.

Score Sheet

The maximum time for this test is 5 minutes.

Action	**Score**
Main Goal	
Move an object next to objects of the same category in the shelf	*5×100*
Misplace an Object	*5×–40*
Request object locations by gesture	*5×–20*
Request object interaction by a human	*5×–60*
Bonus Rewards	
Opening the shelf door	*100*
Moving a *tiny* object	*200*
Moving a *heavy* object	*200*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Using alternative start signal (see sec. 3.7.7)	*–100*
Total Score (excluding penalties and standard bonuses)	*1000*

5.3 Tidy Up

Inside a room in the arena are objects that don't belong there. The robot has to tidy up by bringing them back and throwing any unknown objects into the garbage.
Focus: *System Integration*, *Navigation*, *Computer Vision*, *Object Recognition*, *Manipulation*.

Main Goal

Find 5 misplaced objects in a room and bring them to their predefined locations.
Reward: 500pts (100pts per object)

Bonus Rewards

1. Taking out the garbage (100pts)
2. Moving a *tiny* object (200pts)
3. Moving a *heavy* object (200pts)

Setup and Procedure

- **Location:** A random room in the arena.
- **Instruction:** Nearby the entrance, an operator tells the robot which room to clean.
- **Objects:** There are 5 misplaced objects at random locations in the room. Objects can be anywhere, including the floor, seats, and on furniture. All objects are clearly visible (i.e. no occlusions) and can be:
  - *Known Objects*: Regular, alike, and standard objects.
  - *Unknown Objects*: Garbage lying around (2–3 objects).
- **Heavy and Tiny Objects:** Objects used in this test are lightweight and average-sized. However, the team leader can request a tiny and a heavy object to be used and score additional points for moving them.
- **Bin:** There is an already tied trash bag inside the bin which the robot can bring to a predefined collection zone to score additional points. The unknown objects must be placed or dropped inside the, either emptied or still full, bin.

Additional Rules and Remarks

1. **Partial Scoring:** The main task allows partial (per object) scoring.
2. **Deus ex Machina:** Score reduction for requesting human assistance is applied per object as follows:
   - **Request Object Locations by Speech:** Telling the robot where an object can be found or should be placed causes a reduction of 30pts.
   - **Request Object Locations by Gesture:** Pointing at an object to be picked up or where to place an object causes a reduction of 40pts.
   - **Request Object Locations by Guiding:** Guiding the robot nearby the location where an object can be found or should be placed causes a reduction of 20pts.
   - **Request Object Interaction by a Human:** Having a human pick up or place an object causes a reduction of 60pts.

Referee Instructions

The referee needs to

- Place the objects in the room.
- Recover disposed objects from the bin and place the trash bag inside.
- Ask teams whether they want a heavy or tiny object.

OC Instructions

2 hours before the test:

- Announce the location of the garbage collection zone.

Score Sheet

The maximum time for this test is 5 minutes.

Action	**Score**
Main Goal	
Moving an object to the appropriate location	*5×100*
Request object locations by speech	*5×–30*
Request object locations by gesture	*5×–40*
Request object locations by guiding	*5×–20*
Request object interaction by a human	*5×–30*
Bonus Rewards	
Taking out the garbage	*100*
Moving a *tiny* object to the appropriate location	*200*
Moving a *heavy* object to the appropriate location	*200*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Using alternative start signal (see sec. 3.7.7)	*–100*
Total Score (excluding penalties and standard bonuses)	*1000*

5.4 Carry My Luggage

The robot helps the operator to carry their luggage to a car which is parked outside.
Focus: *System Integration*, *Human-Robot Interaction*, *Person Detection*, *Person Recognition*, *Navigation*, *Mapping*.

Main Goal

The robot helps the operator to carry a bag to a location outside the arena.
Reward: 500pts

Bonus Rewards

1. Re-enter the arena (100 pts)
2. Avoid crowd while following (200pts)
3. Avoid small and hard-to-see objects when going back to arena (50pts each)
4. Avoid retractable barrier (100pts)

Setup and Procedure

- **Location**: The test takes place inside and outside the arena.
- **Start Location**: The robot starts at a predefined location. Time starts when the operator steps in front of the robot.
- **Car Location:** A location outside the arena. Not announced before the test. The operator tells the robot that they reached the car. The main goal is completed when the robot places the bag close to the car location.
- **Bags:** At least two bags (see 3.3.4) are placed near the operator, visible to the robot.
- **Operator**: The operator is standing in front of the robot pointing at the bag to be carried out. The robot should indicate when it is ready to follow. The operator walks naturally towards the car.
- **Obstacles:** On request, 4 obstacles will be placed along the way: (a) the operator moves through a crowd while the robot follows, (b) a small object on the ground, (c) a hard-to-see 3D object, and (d) retractable barriers blocking area near the entrance (robot can still move around it).

Additional Rules and Remarks

1. **Deus ex Machina:** Score reduction for requesting human assistance is applied as follows.
   - **Request Bag Handover**: Asking to hand over the bag causes a score reduction of 100pts.
   - **Re-find by Signaling**: Asking the operator to wave or call causes a score reduction of 100pts.
   - **Re-find by Moving Backwards**: Asking the operator to move backwards causes a score reduction of 250pts.

Referee Instructions

The referees need to

- Choose the car's location.
- Place bags next to operator.
- Place obstacles if requested.

OC Instructions

2h before test:

- Select and announce the robot's starting position.
- Select which bags will be used.
- Recruit volunteers to be the crowd obstructing the path

Score Sheet

The maximum time for this test is 5 minutes.

Action	**Score**
Main Goal	
Take the bag to the car	*500*
Request Bag Handover	*–100*
Re-find by Signaling	*–100*
Re-find by Moving Backwards	*–200*
Bonus Rewards	
Re-enter the arena	*100*
Avoid crowd while following	*200*
Avoid the small object on the ground	*50*
Avoid the hard-to-see 3D object	*50*
Avoid retractable barrier	*100*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Total Score (excluding penalties and standard bonuses)	*1000*

5.5 Receptionist

The robot has to take two new guests to the living room to introduce them and offer a free place to sit.
Focus: *System Integration*, *Human-Robot Interaction*, *Person Detection*, *Person Recognition*.

Main Goal

Introduce and usher two newcomers to a party.
Reward: 500pts (250pts per guest)

Bonus Rewards

1. Open the entrance door to a guest (200pts each)
2. Describe the first guest for the second guest (100pts)

Setup and Procedure

- **Location**: The test takes place in the living room.
- **Start Location**: The robot starts inside the arena at a predefined location near the entrance door.
- **Entrance:** The entrance door is open by default. The team leader can request to close the door to score additional points by opening it for the guests.
- **Host:** The host's name and favorite drink will be announced before the test. The host is already sitting in the living room.
- **Guests:** Both guests have a name and favorite drink. An arriving guest will either step in front of the robot or knock on the closed door. Guests have to be guided to the living room to be introduced.
- **Introductions:** When introducing guests, the robot must clearly identify the person being introduced and state their name and favorite drink. Introducing two people means to introduce them to each other.
- **Seating People:** The robot must point at a place or location where the guest can sit.
- **Switching Places:** Guests may switch places after they were seated.
- **Describing the First Guest:** Naming at least 4 characteristics of the first guest, i.e., color of clothes, color of hair, gender, and age, earns bonus points.

Additional Rules and Remarks

1. **Misunderstanding:** Not understanding the guests and asking them again is fine. Continuing with a wrong name or drink causes a score reduction of 50pts.
2. **Partial Scoring:** The main task allows partial (per guest) scoring.
3. **Deus ex Machina:** Score reduction applies per guest as follows:
    - **Custom Operator:** Since the main focus of the test is HRI, no custom operator can be chosen.
    - **Alternative HRI:** Using an alternative HRI to understand a guest causes a score reduction of 75pts.
    - **Recognizing People:** If the robot has to ask for help to identify people, score is reduced by 200pts.

Referee Instructions

The referees need to

- Assign name and drink to volunteers.
- Arrange (and re-arrange) people in the living room.
- Ask team leader whether to close the door.

OC Instructions

2h before test:

- Announce starting position.
- Announce host's name and favorite drink.
- Recruit volunteers as host and guests.

Score Sheet

The maximum time for this test is 5 minutes.

Action	**Score**
Main Goal	
Introduce a new guest to every other guest and offer a seat	*2×250*
Continue with wrong name or drink	*2×–50*
Alternative HRI	*2×–75*
Recognizing People	*2×–200*
Bonus Rewards	
Open the entrance door for a guest	*2×200*
Describe the first guest to the second guest	*100*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Total Score (excluding penalties and standard bonuses)	*1000*

Chapter 6

Tests in Stage II

Housekeeper

Party Host

6.1 Enhanced General Purpose Service Robot

The robot can be asked to do anything involving abilities required in *Stage I* and *Stage II* of this rulebook.
Focus: *System Integration*.

Main Goal

Execute 3 commands requested by the operator.
Reward: 1500pts (500 points per command)

Bonus Rewards

1. Understand a command given by naive operator (150pts, each)
2. Autonomously leaving the arena (100pts)
3. Complete all 3 commands in time with minimal help (200pts)

Setup and Procedure

1. **Location:** The test mostly takes place inside the arena (some commands might require the robot to go outside).
2. **Instruction Point:** An instruction point is assigned inside the arena where the robot has to go to receive a command.
3. **Operators:** A *professional* operator (i.e. the referee) gives the commands. Optionally, teams can choose to receive commands by a *naive* operator who has no background in robotics, i.e., an audience member. The team can decide to use a *Custom Operator* outright or after the robot fails to understand the professional or naive operator.
4. **Minimal Help:** To score this bonus, the robot needs to complete the commands while requesting relatively few DEMs compared to other teams. This is up to the consideration of the TC.

Additional Rules and Remarks

1. **Not Going to Instruction Point:** If the robot requests commands from somewhere else than the instruction point, a score reduction of 50pts is applied.
2. **Partial Scoring:** The main task allows partial (per command) scoring.
3. **Deus ex Machina:** Score reduction applies per given command as follows:
   - **Custom Operator:** Choosing a custom operator to understand a command causes a score reduction of 100pts.
   - **Alternative HRI:** Using an alternative HRI to understand a command causes a score reduction of 150pts.
   - **Further Assistance:** Helping a robot accomplish a task causes a score reduction in line with 3.8.2 and other *Stage II* tests.

Referee Instructions

- Provide the commands to the operators.
- Make sure the *Arena* is in normal condition.

OC Instructions

2 hours before the test

- Generate commands.
- Announce the location of the instruction point.
- Recruit volunteers to assist during the test.

Score Sheet

The maximum time for this test is 10 minutes.

Action	**Score**
Main Goal	
Complete a command	*3×500*
Receive a command not from the instruction point	*3×–50*
Custom Operator	*3×–100*
Alternative HRI	*3×–150*
Bonus Rewards	
Understand command given by naive operator	*3×150*
Leave the arena autonomously	*100*
Complete all 3 tasks with minimal help	*200*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Using alternative start signal (see sec. 3.7.7)	*–100*
Total Score (excluding penalties and standard bonuses)	*2250*

6.2 P&G Challenge

The robot has to remove all dishes from a table after dinner and place them into the dishwasher.
Focus: *System Integration*, *Manipulation Computer Vision*, *Object Recognition*.

Main Goal

Place all the cutlery and tableware inside the dishwasher.
Reward: 1000pts (150pts per cutlery, 100pts per tableware)

Bonus Rewards

1. Opening the dishwasher door (150pts)
2. Pulling out the dishwasher racks (250pts)
3. Placing a dishwasher tab inside the dishwasher (350pts)

Setup and Procedure

- **Location:** This test takes place in the arena. A dining table is located close to the dishwasher.
- **Table Setting:** Placed on the table are:
  - 8 objects with 4 being cutlery and 4 tableware (see 3.3.4).
  - One dishwasher tab.
- **Dishwasher:** The team chooses whether the dishwasher is open and whether the racks are pulled out.
- **Safe Placing:** Objects must be placed with care. It must be clear that the robot is trying to place the object, not throwing or dropping it.

Additional Rules and Remarks

1. **Placing Objects:** Since placing objects is the main focus of the test, asking a human to place something is not allowed.
2. **Partial Scoring:** The main task allows partial (per object) scoring.
3. **Deus ex Machina:** Score reduction applies per object as follows:
   - **Request Object Handover**: Asking to hand over an object causes a score reduction of 75pts.
   - **Request Object Locations by Gesture:** Pointing at an object to be picked up or where to place an object causes a reduction of 40pts.
4. **Award:** Teams that carry out this task are eligible to win the *Procter & Gamble Dishwasher Challenge Award* and a prize sponsored by P&G. The winner is chosen by representatives of P&G.

Referee Instructions

The referee needs to

- Set the table.
- Arrange the dish washer as requested.

OC Instructions

During Setup days:

- Provide cutlery, tableware, and dishwasher tab for training.

Score Sheet

The maximum time for this test is 10 minutes.

Action	**Score**
Main Goal	
Place tableware inside the dishwasher	*4×100*
Place cutlery inside the dishwasher	*4×150*
Request object locations by gesture	*8×–40*
Request object handover	*8×–75*
Bonus Rewards	
Opening the dishwasher door	*150*
Pulling out the dishwasher racks	*250*
Placing the dishwasher tab inside the dishwasher	*350*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Using alternative start signal (see sec. 3.7.7)	*–100*
Total Score (excluding penalties and standard bonuses)	*1750*

6.3 Restaurant

The robot takes and serves orders to several customers in a real restaurant.
Focus: *System Integration*, *Navigation*, *Mapping*, *Human-Robot Interaction*, *Manipulation*, *Person Detection*, *Object Recognition*.

Main Goal

Take and serve orders from 2 customer.
Reward: 1000pts (500pts per order)

Bonus Rewards

1. Use an unattached tray to transport an order (250pts each)
2. Transport two orders at once (250pts)

Setup and Procedure

- **Location:** A real restaurant fully equipped and in business. There may be real customers and waiters around. The location is not announced beforehand.
- **Start Location:** The robot starts next to the bar.
- **Customers:** There are multiple tables with people. At least two people at different tables have orders. People who want to order wave or call the robot.
- **Orders:** People can order one or two objects. Orders must be placed on the customer's table.
- **Bar:** A table located near the restaurant's kitchen on which objects that can be ordered are placed. All edible/drinkable *Known Objects* can be ordered.
- **Barman:** A member of the TC is standing by the bar to assist the robot on request. The barman will handover orders or place them in a basket or tray.

Additional Rules and Remarks

1. **Safety First:** This test takes place in a public area. Therefore, referees will be more careful and will not tolerate even slight collisions.
2. **Fair Play:** Upon arrival to the restaurant, only two team members are allowed next to the robot. Tweaking, coding, debugging, or mapping the area will lead to immediate disqualification.
3. **Power outlets, WiFi and ECRA:** The availability of wireless, external computing devices, or electrical outlets can't be guaranteed. Assume unavailability.
4. **Disturbances from Outside:** If a person from the audience (severely) interferes with the robot in a way that makes it impossible to solve the task, the teams may repeat the test immediately.
5. **Restart:** This test allows a restart (see 3.7.13).
6. **Partial Scoring:** The main task allows partial (per order) scoring.
7. **Deus ex Machina:** Score reduction applies per order as follows.
    - **Asking for Directions:** Receiving directions, verbally or by pointing, reduces the score by 25pts.

- **Being Guided:** Being guided to a table causes a score reduction of 200pts.
- **Wrong Orders:** Delivering a wrong object reduces score by 350pts if at least part of the order is correct. Reduction of 500pts otherwise.
- **Handing Orders:** Handing objects to the customer instead of placing them causes a score reduction of 100pts.

Referee Instructions

The referee needs to

- Prepare orders for each customer.

OC Instructions

During Setup days:

- Check with local (security) management if the possible location, including a sufficient queuing area, can be used for the restaurant test.

1 hour before the test:

- Gather all teams and robots to move to some nearby queuing area and instruct the teams how/when to move to the actual test location.

Score Sheet

The maximum time for this test is 10 minutes.

Action	**Score**
Main Goal	
Take and serve an order	*2×500*
Request help by receiving directions	*–25*
Request guidance to a table	*–200*
Deliver a partly wrong order	*2×–350*
Deliver a fully wrong order	*2×–500*
Handing over an order instead of placing	*2×–100*
Bonus Rewards	
Use an unattached tray to transport an order	*2×250*
Transport two orders at once	*250*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Total Score (excluding penalties and standard bonuses)	*1750*

6.4 What is That?

A guest asks the robot to identify objects in the household.
Focus: *System Integration*, *Human-Robot Interaction*, *Gesture Recognition*, *Computer Vision*, *Object Recognition*.

Main Goal

The robot names 5 objects, the guest is pointing at.
Reward: 1000pts (200pts per object)

Bonus Rewards

1. The robot understands two different non-verbal commands, e.g., nodding, gesturing for the robot to follow (250pts)
2. The robot names one feature that is unique to the object in its group (100pts, each)

Setup and Procedure

1. **Location:** This test takes place inside the *Arena*.
2. **Groups of Objects:** There are five groups of 2–5 *Known Objects* randomly placed on the floor.
3. **Guest:** The guest is one of the referees. They will step in front of the robot after it enters the *Arena*. Then, the guest guides the robot to a group of objects where they point at one.
4. **Naming:** The robot needs to tell the guest the official name of the object.
5. **Skipping Groups:** The robot can decide to pass on an object. The guest will move on to the next group. They robot cannot request to go back at a later time.
6. **Non-Verbal Commands:** The team leader can tell the referee that the robot can recognize non-verbal commands. The team is not allowed to instruct the guest. Interaction must be guided by the robot.

Additional Rules and Remarks

1. **Partial Scoring:** The main task allows partial (per object) scoring.
2. **Deus ex Machina:** Score reduction applies per object as follows:
   - **Asking Yes or No Questions:** Asking yes or no questions about the object (e.g. Is the object yellow?), reduces the score by 50pts.
   - **Asking Attribute Questions:** Asking questions about attributes of the object (e.g. What color is the object?), reduces the score by 100pts.
   - **Interacting with Objects:** Asking the operator to pick up the object or move it closer reduces the score by 150pts.

Referee Instructions

The referee needs to

- Place the groups of objects.
- Choose which objects to point at.

Score Sheet

The maximum time for this test is 10 minutes.

Action	Score
Main Goal	
Correctly name an object	*5×200*
Ask yes or no question	*–50*
Ask question about an attribute of the object	*–100*
Request help by asking the operator to move the object closer	*–150*
Bonus Rewards	
Understand two different non-verbal commands	*250*
Describe unique feature of object	*5×100*
Special Penalties & Bonuses	
Not attending (see sec. 3.9.1)	*–500*
Using alternative start signal (see sec. 3.7.7)	*–100*

Total Score (excluding penalties and standard bonuses) *1750*

Chapter 7

Finals

The competition ends with the *Finals* on the last day, where the two teams with the highest total score compete. The *Finals* are conducted as an open, themed demonstration. The *Finals* of each league is scheduled at different times.

7.1 Structure and Theme

To give a better basis to the juries and the audience on how to evaluate the performances, each year the *Finals* have a theme which is stated as an objective. The themes for this year are:

OPL/DSPL: The robot serves food to a user. (TODO: new theme for this year)
SSPL: The robot naturally interacts with a non-expert user. (TODO: new theme for this year)

Teams are free to use anything from the @Home scenario (see 3.3) and to chose participants from other teams, the jury, or the audience. The themes are open to allow teams to create a story around them which incorporates additional tasks and abilities the team wants to present. Teams may provide a printed document to the jury (max 1 page) that summarizes the demonstrated robot capabilities and contributions. However, teams are discouraged to provide any material that would distract from their demonstration. It is recommended to spend only a short amount of time to explain the demonstration and rather let it speak for itself.

7.2 Juries and Evaluation Criteria

The *Finals* are evaluated by two juries:

1. **League-Internal Jury:** Formed by the *Executive Committee* (EC). The evaluation is based on the following criteria:
   1.1. Efficacy/elegance of the solution.
   1.2. Innovation/contribution to the league.
   1.3. Difficulty of the overall demonstration.
   1.4. Fit to the Theme.
2. **League-External Jury:** Consists of people not being involved in RoboCup@Home, but with related background (not necessarily robotics). They are appointed by the EC. The evaluation of the league-external jury is based on the following criteria:
   2.1. Originality and presentation (story-telling is to be rewarded).
   2.2. Relevance/usefulness to everyday life.
   2.3. Elegance/success of overall demonstration.
   2.4. Fit to the Theme.

7.3 Procedure

1. **Schedule:** The team in 2nd place goes first, followed by the current 1st place.
2. **Time:** The total time is 15 min, 10 for setup and demonstration and 5 for questions and clean up.
3. **Setup and Demonstration:** The team has to setup, introduce and present their demonstration. The *Arena* will be in its default state except for the jury area which is announced beforehand.
4. **Interview and Cleanup:** Members of both juries can ask questions. During this time, the team has to undo any changes made to the *Arena* during their demonstration.

7.4 Scoring

The final score and ranking are determined by the jury evaluations and by the previous performance (in *Stage I* and *Stage II*) of the team, in the following manner:

1. The influence of the league-internal jury to the final ranking is 25 %.
2. The influence of the league-external jury to the final ranking is 25 %.
3. The influence of the total sum of points scored by the team in Stage I and II is 50 %.

7.5 Final Ranking and Winner

There will be an award for 1st, 2nd and 3rd place of each league.
The winner of the competition is the team that gets the highest ranking in the *Finals*.
The second place will be the team that got the second-highest ranking in the *Finals*.
The third place will be the team with the highest score that did not make it to the *Finals*.
Additional certificates are granted if:

1. the number of teams in the league is above 11, a certificate will be awarded to the 4th ranked team.
2. the number of teams in the league is above 14, a certificate will be awarded to the 5th ranked team.

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