



RoboCup@Home

Rules & Regulations

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This is the official rulebook of the RoboCup@Home competition 2022. The rulebook has been written by the 2022 RoboCup@Home Technical Committee.

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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 ROBOCUP@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 abilities and performance of different robots in a realistic, non-standardized home environment setting. The focus is on, but is not limited to, the following domains: human-robot interaction and cooperation, navigation and mapping in dynamic environments, computer vision and object recognition under natural light conditions, object manipulation, adaptive behaviors, behavior integration, ambient intelligence, standardization and system integration. The competition is co-located with the RoboCup symposium.

1.3 Organization

@HOME is organized into three subcommittees. The current members of the committees are listed at <https://athome.robocup.org/committees/>.

1.3.1 Executive Committee — ec@robocupathome.org

The *executive committee* (EC) consists of members of the board of trustees, and representatives of each activity area, and supervises both the TC and OC. The committee is responsible for the long-term planning of the league and cast the final vote in all decisions within the competition, including those pertaining to any of the committees and any other affair that requires a qualified vote. Additionally, the EC must act when any of the committees fail, as it responds to the Trustee board and directs the league accordingly.

1.3.2 Technical Committee — tc@robocupathome.org

The *technical committee* (TC) is responsible for the rules of the league; its main focus is writing the rulebook and refereeing. The members of the EC are always members of the TC as well.

1.3.3 Organizing Committee — oc@robocupathome.org

The *organizing committee* (OC) is responsible for the organization of the competition, namely it creates the schedule and provides information about the scenarios. The *Local Organizing Committee* (LOC), on the other hand, is responsible for the set up and organization of the competition venue.

1.4 Infrastructure

RoboCup@Home Mailing List The official @HOME mailing list can be found 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* is hosted 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 @HOME league. The wiki was set up to simplify and unify the exchange of relevant information; this includes, but is 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 into three Leagues. One of these grants complete freedom to all competitors with respect to the robot used, while two of them are *Standard Platform Leagues* (SPLs), namely all competitors use the same robot. The official leagues and their names are:

- *Open Platform League* (OPL)

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

Each league focuses on a different aspect of service robotics by targeting specific abilities.

1.5.1 Domestic Standard Platform League (DSPL)

The main goal of the DSPL is to assist humans in a domestic environment, paying special attention to elderly people and people suffering from illness or disability. As a consequence, the DSPL focuses on *Ambient Intelligence*, *Computer Vision*, *Object Manipulation*, safe indoor *Navigation* and *Mapping*, and *Task Planning*. The robot used in the DSPL is the *Toyota HSR*, shown in Figure 1.1.



Figure 1.1: Toyota HSR

1.5.2 Social Standard Platform League (SSPL)

The SSPL takes robots away from a traditional passive servant role, as the robot is now the one who actively looks for interaction. From a party waiter in a domestic environment to a hostess in a museum or shopping mall, in SSPL we look for the next user who may require the robot's services. Hence, this league focuses on *Human-Robot Interaction*, *Natural Language Processing*, *Person Detection* and *Person Recognition*, *Adaptive Behaviors*, and safe outdoor *Navigation* and *Mapping*. The robot to be used in the SSPL is the *Softbank Pepper*, shown in Figure 1.2.

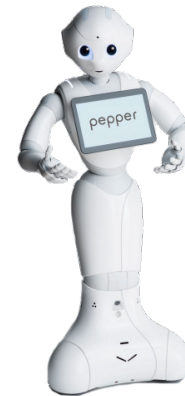


Figure 1.2: Softbank / Aldebaran Pepper

1.5.3 Open Platform League (OPL)

The OPL has had the same modus operandi since the foundation of @HOME. With no hardware constraints, OPL is the league for teams who want to test their own robot designs and configurations, as well as for old at-homers. In this league, robots are tested to their limits without having in mind any concrete design restriction, although the scope is similar to the DSPL.

1.6 Competition

The competition consists of two *Stages* and a *Final*. Each stage consists of a series of *Tests* that are being held in a daily life environment. The best teams from *Stage I* advance to *Stage II*, which consists of more difficult tests. The competition ends with the *Final*, where only the two highest-ranked teams of each league compete to select the winner.

1.7 Awards

The @HOME league features the *awards* described below. Note that all awards need to be approved by the *RoboCup Federation* (RCF); based on a decision by the RCF, some of them

may not be given.

1.7.1 Winner of the Competition

For each league, there will be 1st, 2nd, and 3rd place award trophies (or first and second place only if the number of teams in a league is eight or less).

1.7.2 Best Human-Robot Interface Award

To honor outstanding human-robot interfaces developed for interacting with robots in @HOME, a special *Best Human-Robot Interface Award* may be given to one of the participating teams. Special attention is paid to making the interface open and available to the @HOME community.

The @HOME EC members nominate a set of candidates for the award and the TC elects the winner. A TC member whose team is among the nominees is not allowed to vote. There is no *Best Human-Robot Interface Award* in case the EC decides that there is no outstanding interface, and thus no nominees.

1.7.3 Best Poster Award

To foster scientific knowledge exchange and reward the teams' efforts to present their research contributions, all scientific posters of each league are evaluated and have the chance of receiving the *Best DSPL Poster Award*, the *Best OPL Poster Award*, or the *Best SSPL Poster Award*, respectively.

Candidate posters must present innovative and state-of-the-art research within a field with a direct application to @HOME, and demonstrate successful and clear results in an easy-to-understand way. In addition to being attractive and well-rated in the *Poster Session* (see Section 4.3), the described research must have impact in the team's performance during the competition.

The @HOME EC members nominate a set of candidates for the award and the TC elects the winner. A TC member whose team is among the nominees is not allowed to vote.

1.7.4 Open Challenge Award

To encourage teams to present their research to the other teams in the competition off-hours, @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; thus, the award is not necessarily granted.

The @HOME TC members, with a recommendation from the team leaders, nominate a set of candidates for the award; the EC decides if the award should be granted and elects the winner. A TC member is not allowed to nominate their own team without a recommendation from the team leaders.

1.7.5 Skill Certificates

The @HOME league features certificates for best demonstrated skills in *Navigation*, *Manipulation*, *Person Recognition*, and *Natural Language Processing*. A team is given the certificate if it scores at least 75% of the attainable points for that skill. This is counted over all tests and

challenges, so, for example, if a robot scores manipulation points during the *Help-me-Carry* test to open the door, that will count for the *Manipulation* certificate. Note that the certificate will only be handed out if the team is *not* the overall winner of the competition.

1.7.6 Open-source software award

Since Nagoya 2017, RoboCup@Home awards the best contribution to the community by means of an open source software solution. To be eligible for the award, the software must be easy to read, have proper documentation, follow standard design patterns, be actively maintained, and meet the 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 TC at least one month before the competition by means of a short paper (maximum 4 pages), following the same format used for the *Team Description Paper* (TDP) (see Section 3.1.2), including 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 being described.

The @HOME TC members nominate a set of candidates for the award and the EC elects the winner. An EC/TC member whose team is among the nominees is not allowed to vote.

Chapter 2

Concepts Behind the Competition

A set of conceptual key criteria builds the basis for the ROBOCUP@HOME competition. These criteria are to be understood as a common agreement on the general concept of the competition. The concrete rules are listed in Chapter 3.

2.1 Lean Set of Rules

To allow for different, general, and transmissible approaches in the @HOME competition, the rule set should be as lean as possible. Nonetheless, to avoid rule discussions during the competition itself, it should also be concrete enough to leave no room for diverse interpretations. If, during a competition, there are any discrepancies or multiple interpretations, a decision will be made by the TC and the referees on site.

Note: Once the test scoresheet has been signed or the scores has been published, the TC decision is irrevocable.

2.2 Autonomy & Mobility

The aim of @HOME is to foster mobile autonomous service robotics and natural human-robot interaction. Thus, all robots participating in the RoboCup@Home competition must be *mobile* and *autonomous*, which means that humans are not allowed to directly (remotely) control the robot (this also includes verbally remotely controlling the robot).

2.3 Aiming for Applications

To foster the advance in technology and to keep the competition interesting, the scenario and the tests will steadily increase in complexity. While necessary individual abilities are still being tested in the competition, tests will focus more and more on real applications with a rising level of complexity and uncertainty. Useful, robust, general, cost effective, and applicable solutions are rewarded in @HOME.

2.4 Social Relevance

The competition and the included tests should produce socially relevant results, as the aim is to convince the public about the usefulness of autonomous robotic applications. This should

be done by showing applications where robots directly help or assist humans in everyday life situations. Examples of such applications are: a personal robot assistant, a guide robot for the blind, robot care for elderly people, and so forth. Such socially relevant results are rewarded in @HOME.

2.5 Scientific Value

@HOME should not only show what can be put into practice today, but should also present new approaches, even if they are not yet fully applicable or if they demand a very special configuration or setup. Therefore, a high scientific value of an approach is rewarded.

2.6 Time Constraints

To allow for many participating teams and tests as well as to foster a simple setup procedures, the setup time and the time for performing the tests is very limited.

2.7 No Standardized Scenario

The scenario for the competition should be simple but effective, available world-wide, and at low cost. As uncertainty is part of the concept, no standard scenario will be provided in @HOME. One can expect that the scenario will look typical for the country where the competition is hosted.

The scenario is something that people encounter in daily life; this can be a domestic environment, such as a living room and a kitchen, but also an office space, a supermarket, a restaurant, etc. The scenario should change from year to year, as long as the desired tests can still be executed. Furthermore, tests may take place outside of the scenario, that is, in a previously unknown environment, such as a public space nearby.

2.8 Attractiveness

The competition should be attractive for the audience and the public; thus, high attractiveness and originality of an approach will be rewarded.

2.9 Community

While they have to compete against each other during the competition, the members of the @HOME league are expected to cooperate and exchange knowledge to advance technology together. The *RoboCup@Home mailing list* as well as the *Rulebook Repository* can be used to get in touch with other teams and to discuss league-specific issues such as rule changes, proposals for new tests, etc. In addition, every team is expected to share relevant technical, scientific (and team-related) information in their TDP (see Section 3.1.2) and on the team's website.

Finally, all teams are invited to submit papers on related research to the ROBOCUP SYMPOSIUM, which accompanies the annual RoboCup World Championship.

2.10 Desired Abilities

The following is a list of desired technical abilities that the tests in @HOME are focusing on:

- Navigation in dynamic environments
- Fast and easy calibration and setup (the ultimate goal is to have a robot up and running out of the box)
- Object recognition
- Object manipulation
- Detection and recognition of humans
- Natural human-robot interaction
- Speech recognition
- Gesture recognition
- Robot applications (@HOME is aiming for applications of robots in daily life)
- Ambient intelligence, such as communicating with surrounding devices, retrieving information from the internet, etc.

Chapter 3

General Rules and Regulations

These are the general rules and regulations for the competition in the ROBOCUP@HOME league. Every rule in this section can be considered to implicitly include the term “*unless stated otherwise*”. This means that additional or contrary rules, in particular with respect to the specification of tests, have a higher priority than those mentioned in the general rules and regulations.

3.1 Team Registration and Qualification

3.1.1 Registration and Qualification Process

Each year, there are three phases in the process towards participation in @HOME:

1. *Preregistration*
2. *Qualification* announcement
3. Final *Registration* for qualified teams

The preregistration will be announced by a call for participation sent to the *RoboCup@Home mailing list*. Preregistration requires a *team description paper*, a *video* and a *website*. The expected contents of these are described below.

3.1.2 Team Description Paper

The *Team Description Paper* (TDP) is an 8-pages long scientific paper, which must include a description of your main research, including the scientific contribution, goals, scope, and results. The TDP has to be written in English and formatted using the template of the RoboCup International Symposium without any alterations. The paper should contain the following items:

- The focus of research and the contributions in the respective fields
- Innovative technology (if any)
- Re-usability of the system for other research groups
- Applicability of the robot in real-world scenarios
- Photo(s) of the robot(s) used

As an appendix on the 9th page (after the references), please include:

- Team name
- Contact information
- Website URL
- Names of the team members

- Photo(s) of the robot(s), unless included before
- Description of the hardware used
- A brief, compact list of *external devices* (see Section 3.5), if any
- A brief, compact list of any used 3rd party software packages (e.g. ROS' `object_recognition` should be listed, but `OpenCV` doesn't have to be because it is a rather standard library)
- [**Open Platform League only**] A brief description of the hardware used by the robot(s)

During the qualification process, the TDP will be scored according to its scientific value, novelty, and contributions.

3.1.3 Qualification Video

As a proof of running hardware, each team has to provide a *qualification video* that shows at least two of the following abilities (as a minimum requirement):

- Human-robot interaction
- Safe navigation (indoors, with obstacle avoidance)
- Object detection and manipulation
- People detection
- Speech recognition
- Speech synthesis (clear and loud)

Showing some of the following abilities is also recommended:

- Activity recognition
- Complex speech recognition
- Complex action planning
- Gesture recognition
- Failure recovery

The video should not exceed the average time for a test (max. 10 min), should be self-explanatory and designed for a general audience, and should show the robot solving complex tasks relevant for @HOME. In particular, to qualify for the competition, the video should show that the robot is able to successfully solve at least one test from the current or previous year's rule book. For robots moving slowly, we suggest to speed-up videos, but please indicate the speed factor being used when doing so (e.g. 2x); the same rule applies for slow motion scenes.

3.1.4 Team Website

The *team website* should be designed for a broader audience and include scientific material (scientific papers, datasets, and documented open source code). The requirements for the website are as follows:

1. **Language:** The team website has to be in English. Other languages may be also available, but English must be default language.
2. **Team:** A comprehensive list of all team members, including brief profiles.
3. **RoboCup:** Link to the league website and previous participations of the team at ROBOCUP (not necessarily only @HOME).

4. **Scientific approach:** Include a research statement, a description of the used approach, and information on scientific achievements.
5. **Publications:** Relevant *publications* from at least the last five years should be included. Downloadable publications are scored higher during the qualification process.
6. **Open source material:** Blueprints, datasets, repositories, or any other kinds of contributions to the league are scored highly during the qualification process.
7. **Multimedia:** Photos and videos of the robot(s) used should be included and easy to find.

3.1.5 Qualification

During the *qualification process*, a selection will be made by the OC. The following points are taken into account and evaluated in the decision process:

- The scientific value, novelty, and contributions of the TDP
- The number of abilities and the complexity of the tasks shown in the qualification video
- The contents of the team website, where relevant publications and open source resources are valued highly

In addition, the following evaluation criteria are considered:

- The performance in previous competitions
- Relevant scientific contributions and publications
- Any additional contributions to the @HOME league

Important note for the Standard Platform Leagues: Only unmodified robots may compete in Standard Platform Leagues. Any *unauthorized* modification made to the robot that are found in the qualification material will automatically disqualify the team in the qualification process.

3.1.6 Participation Confirmation

In order to have as many participating teams as possible, qualified teams *must* contact the OC to confirm (or cancel) the participation several months in advance. Confirming attendance implies that the team has sufficient resources to register for the competition and commits to attend the event. Qualified teams that do not confirm their participation may be disqualified.

3.2 Audience interaction

Part of making ROBOCUP@HOME appealing is to show the audience what robots should do and what they are actually doing during tasks. In particular, providing information about what a robot is doing to the audience is important for the advancement of the league. To this end, robots in @HOME are expected to run the ROBOCUP@HOME [VizBox](https://github.com/LoyVanBeek/vizbox)¹, which is a web server to be run on a robot during a task. The page it serves can be displayed on a screen and is visible to the audience via a secondary computer in or around the *Arena*, which is connected to the web server via the wireless network. The *VizBox* can:

¹<https://github.com/LoyVanBeek/vizbox>

- display images of what a robot can see, such as camera images, or a visualization of the robot’s world model, the robot’s map, or anything else that clarifies what the robot is trying to do
- show an outline of the current tasks and the robot’s current state in it
- display subtitles of the conversation between a robot and an operator

Additionally, the *VizBox* offers a way to input text commands to the robot so that automatic speech recognition can be bypassed, if necessary.

The documentation of the component is maintained in the *VizBox* repository. All teams should ideally run the same *VizBox* code, as the audience should be shown a consistent presentation; however, opening a pull request to share any changes is much appreciated so that all teams can benefit from them.

3.3 Scenario

Most competition tests take place in the *ROBOCUP@HOMEArena*, but some tests may take place outside, in a previously unknown public place. In this section, the *Arena* and its contents are described, in particular the furnishing and other information that is common between tests and leagues.

3.3.1 RoboCup@Home Arena

The *ROBOCUP@HOMEArena* is a realistic home setting (an apartment) consisting of interconnected rooms. The minimal configuration consists of:

- a bedroom,
- a dining room,
- a living room, and
- a kitchen

There is usually one *Arena* per league. Depending on the local organization, there may also be multiple *Arenas* that may be different from each other, and a robot must be prepared to perform any task in any *Arena*.

The arena is arranged and decorated to resemble a typical apartment in the hosting country, including all necessities and decorations one can expect to find in a *normal* home. Note that what is considered *normal* may vary greatly based on the culture and location where *ROBOCUP* is hosted. Decorations may include, but are not limited to, plants, mirrors, paintings, posters, plates, picture frames, wall clocks, candles with holders, and books.

3.3.2 Walls, Doors, and Floor

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

1. **Walls:** Walls are fixed and cannot be modified during the competition. The minimum wall height is 60 cm; a maximum height is not specified, but must allow the audience to watch the competition.



Figure 3.1: An example of a ROBOCUP@HOMEscenario

2. **Doors:** Inside the *Arena*, rooms are connected by doors (at least one). All doors have handles, not knobs, and can be closed at any time; it is thus expected that robots are either able to open them or find a plan around them.
3. **Floor:** The floor and doorways of the *Arena* are even, so there are no significant steps or stairways; however, minor unevenness, such as carpets, transitions in floor covering between different areas, and minor gaps (especially at doorways) can be expected.
4. **Appearance:** The floor and walls are mostly monochromatic, but may contain textures, such as a carpet on the floor, or a poster or picture on the wall.

3.3.3 Furniture

The *Arena* is furnished with typical objects common for the host country. The minimal configuration consists of:

- a bed,
- a couch,
- a small table,
- a small dinner table with two chairs,
- two trash bins,
- an open cupboard or a small table with a television and remote control,
- a cupboard with drawers,
- a bookcase, and
- a coat rack

The *Arena*'s kitchen has:

- a dishwasher,
- a microwave,
- a sink, and
- a refrigerator (with some cans and plastic bottles inside)

A typical *Arena* setup is shown in Figure 3.1a.

Cupboard

The cupboard can be any shelf-like furniture in which objects can be placed, such that the minimum distance between shelves is 30 cm and at least two drawers are between 90 cm and 120 cm from floor level. The cupboard may have doors.

Fridge

At least one powered and functioning fridge is required in the *Arena*. The fridge must not be smaller than 120 cm.

3.3.4 Changes to the *Arena*

Since 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 (at a *Predefined Location* or not) that cannot be expected to be fully static in an everyday environment might be moved slightly between tests. In particular, furniture will not change rooms or move drastically inside a room, but a couch or table may be slightly rotated or moved; fixed locations for such furniture items should not be assumed. 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.

3.3.5 Objects

Some tests in the RoboCup@Home league involve recognizing and manipulating objects (see Figure Figure 3.1b). The TC will compile a list of at least 30 objects for this purpose; the list will contain a picture of the each object, as well as its official name and *Object Category* (for instance, an *Apple* belongs to the *Fruits* category). Most objects are likely to be lightweight and easy to grasp with one hand. Every *Object Category* has an assigned *Predefined Location*, where objects of that category can usually be found during tests (for example, an *Fruits* can be found on the *Kitchen Table*); assignments are announced during the *Setup Days* (see 4).

Objects are provided at the competition for training. Teams may keep at most five training objects at a time and for at most one hour. Modifying the training objects is not allowed.

Two types of objects are used in the tasks:

1. **Known Objects:** Objects previously known to the robot, divided into:
 - 1.1. **Consistent Objects:** Objects whose image appears in the list of objects.
 - 1.2. **Similar Objects:** Objects whose image is not present in the list of objects, but look similar enough to one of them that a person would consider them the same kind of object. For example, an apple whose color is different from the apple in the list of objects, or a piece of cloth with a different pattern.

- 1.3. **Standard Objects:** Objects chosen from the *YCB Dataset*.² They are published 6 months in advance on the ROBOCUP@HOME website³, so that they can be acquired 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).

The minimal configuration of *Known Objects* consists of:

- **Tableware:** Dish, bowl, cup (or mug), and napkin (see Figure 3.2a).
- **Cutlery:** Fork, knife, and spoon.
- **Trash Bags:** Big plastic trash bags, preferably with a handle.
- **Bags:** Lightweight and with stiff, vertical handles (see Figure 3.2b).
- **Disks or books:** A set of discs (LP, CD, DVD, or BluRay) or books.
- **Coat rack:** A rack or pole to hang coats and other clothes.
- **Trays:** A transport object such as a tray or basket, intended for bimanual manipulation (see Figure 3.2c).
- **Pourable:** An object whose content can be poured (such as a cereal box).
- **Heavy object:** Weight between 1.0kg and 1.5kg.
- **Tiny object:** A lightweight object that is not bigger than 5 cm (such as paper, a teabag, or a pen).
- **Fragile object:** An easy-to-break object, (such as a chocolate egg).
- **Deformable object:** A flexible object that may take different shapes (such as cloth).
- **Garbage bag:** A garbage bag that can be tied.



Figure 3.2: Example of object containers

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 (such as red, blue, black with white dots, etc.).
- Relative estimated size (smallest, largest, big one, etc.).
- Relative estimated weight (lightest, heaviest).
- Relative position (left of, rightmost, etc.).
- Object description (is fragile, is a 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.

²<http://www.ycbbenchmarks.com/object-set/>

³<https://athome.robocup.org/standard-objects>

3.3.6 Predefined Rooms and Locations

Some tests in the RoboCup@Home league involve a *Predefined Location* where people or objects can be found. Each *Predefined Location* has an assigned *Location Class* (for instance, a *Couch* and an *Arm Chair* belong to the *Seating* class). There will also be at least two *doors*, named an *Entrance* and an *Exit*, which lead in and out of the *Arena*, respectively. Room names, predefined locations, and location classes are announced during the *Setup Days* (see 4).

3.3.7 Predefined Person Names

Some tests in the RoboCup@Home league involve memorizing a person's name. All people in the *Arena* have an assigned *Predefined Name* chosen by the TC. The list of names contains 25 % male, 25 % female, and 50 % gender-neutral names taken from the list of most commonly used names in the United States. Predefined names are announced during the *Setup Days* (see 4).

3.3.8 Wireless network

For wireless communication, an *Arena Network* is provided. The actual infrastructure depends on the local organization. Reliability and performance of the network is not guaranteed; robots are expected to be able to run without a wireless network.

The following rules apply:

- Only the *Arena Network* can be used during tests.
- Only the active team in a task is allowed to use the *Arena Network*.
- The *Arena Network* provides one Virtual Local Area Network (VLANs) per team.
- Each VLAN is most likely to have its own SSID/password.
- VLAN traffic is separated from any other team and is 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 their devices may be temporarily confiscated by the OC; this includes smartphones and concealed SSIDs. It is thus advised to verify your devices for any breaches of this nature.

3.4 Robots

3.4.1 Number of Robots

1. **Registration:** The maximum *number of robots* per team is *two* (2).
2. **Regular Tests:** Only one robot is allowed per test. For different test runs, different robots can be used.
3. **Final:** In the *Final*, 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:

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

The compliance with these rules will be verified during *Robot Inspection* (see 4.4).

3.4.3 Standard Platform Leagues

Standardized platforms allow teams to compete under equal conditions by eliminating all hardware-dependent variables from the tasks; therefore, *unauthorized* 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 Section 3.9.2). Robots are, however, allowed to “wear” clothes, have stickers (such as a sticker exhibiting the logo of a sponsor), or be painted (provided that the robot provider has approved that).

All modifications to the robots will be examined during the *Robot Inspection* (see 4.4). Note that the EC and TC members may request re-inspection of an SPL robot at any time during the competition.

Authorized DSPL Modifications

In the *Domestic Standard Platform League* (DSPL), teams may use an external laptop, which is safely located in the official *Mounting Bracket* provided by Toyota and is connected to the *Toyota HSR* via an Ethernet cable. Any laptop fitting inside the *Mounting Bracket* is allowed to be used, regardless of its technical specification. Furthermore, teams are allowed to attach the following devices to either the *Toyota HSR* or the laptop in the *Mounting Bracket*:

- **Audio:** A USB audio output device, such as a USB speaker or a sound card dongle.
- **Wi-Fi adapter:** A USB-powered IEEE 802.11ac (or newer) compliant device.
- **Ethernet Switch:** A USB-powered IEEE 802.3ab (or newer) compliant device.

In all cases, a maximum of three such devices can be attached, such that they may not increase the robot’s dimensions. For this purpose, using short cables and attaching the devices to the laptop in the *Mounting Bracket* is advised.

3.4.4 Robot Specifications for the Open Platform League

Robots competing in the RoboCup@Home Open Platform League must comply with security specifications in order to avoid causing any harm while operating.

Size and Weight

1. **Dimensions:** The dimensions of a robot should not exceed the limits of an average door (200 cm by 70 cm in most countries). The TC may allow the qualification and registration of larger robots, but, due to local restrictions, it cannot be guaranteed that the robots can actually enter the *Arena*. In doubt, please contact the *Local Organizing Committee* (LOC).
2. **Weight:** There are no specific weight restrictions; however, the weight of the robot and the pressure it exerts on the floor should not exceed local regulations for the construction of offices and/or buildings which are used for living in the country where the competitions is being held.
3. **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 quickly and easily.

Appearance

OPL robots should have an appearance that resembles a safe and finished product rather than an early stage prototype. This, in particular, means that the robot's internal hardware (electronics and cables) should be completely covered so that safety is ensured. Please note that covering the robot's internal hardware with a t-shirt is not forbidden, but is not advised.

Emergency Stop Button

1. **Accessibility and visibility:** Every robot has to provide an easily accessible and visible *Emergency Stop* button.
2. **Color:** The *Emergency Stop* 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 buttons present on the robot.
3. **Robot behavior:** When the *Emergency Stop* button is pressed, the robot and all its parts must stop moving immediately.

Start Button

1. **Requirements:** As explained in Section 3.7.8, teams that aren't able to carry out the default start signal (opening the door) have to provide a *Start Button* that can be used to start tests. Teams need to announce this to the TC before every test that involves a start signal, including the *Robot Inspection*.
2. **Definition:** The *Start Button* can be any "one-button procedure" that can be easily executed by a referee (such as releasing the *Emergency Stop*, a green button, or a software button in a graphical user interface).

Note: All robot requirements will be tested during the *Robot Inspection* (see 4.4).

3.5 External devices

Everything that a team uses during a test and is not part of the robot is considered an *External Device*. All *External Devices* must be authorized by the *technical committee* (TC) during the *Robot Inspection* test (see Section 4.4). The TC specifies whether an *External Device* can be used freely or under referee supervision, and determines its impact on scoring.

Note that the use of wireless devices, such as hand microphones and headsets, is not allowed, with the exception of *External Computing* as specified below. Please also note that the competition organizers do not guarantee or take any responsibility regarding the availability or reliability of the network or the internet connection in the *Arena*. Teams can thus use *External Computing* resources at their own risk.

3.5.1 On-site External Computing

Computing resources that are not physically attached to the robot are considered *External Computing* resources. The use of up to five *External Computing* resources is allowed, but only in the *Arena Network* (see Section 3.3.8) and with a prior approval of the TC. Teams must inform the TC about the use of any *External Computing* at least one month before the competition. Note, however, that robots must be able to operate safely even if *External Computing* is unavailable.

External Computing devices must be placed in the *External Computing Resource Area* (ECRA), which is announced by the TC during the *Setup Days*. A switch connected to the *Arena* wireless network will be available to teams in the ECRA. During a *Test Block*, at most two laptops and two people from different teams are allowed in the ECRA simultaneously, one member each of the teams up next. No peripherals, such as screens, mice, keyboards, and so forth, are allowed to be used.

During a *Test Slot*, everyone must stay at least 1 m away from the ECRA. Interacting with anything in the ECRA after the referee has given the start signal for a test will result in the test being stopped with a score of zero.

If a laptop is used as *External Computing*, a team can only place it in the ECRA if their *Test Slot* is up next and must remove the device immediately after the test.

3.5.2 On-line external computing

Teams are allowed to use *External Computing* through the internet connection of the *Arena Network*; this includes cloud services or online APIs. These must be announced to and approved by the TC one month prior to the competition.

3.6 Organization of the Competition

3.6.1 Stage System

The competition features a *stage system*, namely it is organized in two stages, each consisting of a number of specific tasks, and ends with a *Final*.

1. **Robot Inspection:** For security, robots are inspected during the *Setup Days*. A robot must pass the *Robot Inspection* test (see Section 4.4) so that it is allowed to compete.

2. **Stage I:** The first days of the competition are called *Stage I*. All qualified teams that have passed the *Robot Inspection* can participate in *Stage I*.
3. **Stage II:** The best 50% of teams after *Stage I* advance to *Stage II*. If the total number of teams is less than 12, up to 6 teams may advance to *Stage II*. In this stage, tasks require more complex abilities or combinations of abilities.
4. **Final:** The best two teams of each league, namely the ones with the highest score after *Stage II*, advance to the *Final*. The final round features only a single task integrating all tested abilities. In order to participate in the *Final*, a team must have solved at least one of the *Stage II* tasks.

Note that the same task can be performed multiple times during *Stage I* and *Stage II* (see Section 3.6.3). In case of having no considerable score deviation between a team advancing to the next stage and a team dropping out, the TC may announce additional teams advancing to the next stage.

3.6.2 Schedule

1. **Test Blocks:** For each test one Test Block is scheduled during which each (qualified) team gets at least two Test Slots assigned. With the Restaurant test being the exception where only one Test Slot is assigned.
2. **Test Slots:** During a Test Slot a team has the amount of time specified for the test to attempt to solve it.
3. **Participation is default:** Teams have to inform the OC in advance if they are skipping a Test Block. Without such indication, they may receive a penalty when not attending (see Section 3.9.1).
4. **GPSR Block:** During the GPSR slot teams are allowed to perform one Stage 1 test of their choice instead, to allow more attempts for newer or specialized teams. Note that participation in GPSR is mandatory to advance to Stage 2.

	Day 1	Day 2	Day 3	Day 4
Block 1 (9:00–11:00)	Carry my Luggage	Take out the Garbage	Restaurant	
	—Break—			Finals
Block 2 (13:00–15:00)	Receptionist	GPSR	TBD	
	Stage 2			
Block 3 (17:00–19:00)	Storing Groceries	Clean the Table	EGPSR	

Table 3.1: Example schedule. Each team has at least two Test Slots assigned in every Test Block.

Note that the actual allocation of blocks will be announced by the OC during the *Setup Days* (see Table 3.1).

3.6.3 Scoring System

Each task has a main objective and a set of bonus scores. To score in a test, a team must successfully accomplish the main objective of the task; bonuses are not awarded otherwise.

The scoring system has the following constraints:

1. **Stage I:** The maximum total score per task in *Stage I* is *1000 points*.
2. **Stage II:** The maximum total score per task in *Stage II* is *2000 points*.
3. **Final:** The final score is normalized.
4. **Minimum score:** The minimum total score per test in *Stage I* and *Stage II* is *0 points*. In principle, teams cannot receive negative points, except if they receive penalties. In particular, both penalties for not attending (see Section 3.9.1) and extraordinary penalties (see Section 3.9.2) can result in a total negative score.

3.7 Procedure during Tests

3.7.1 Safety First!

1. **Emergency Stop:** At any time when operating the robot inside and outside the scenario the owners have to stop the robot immediately if there is a remote possibility of dangerous behavior towards people and/or objects.
2. **Stopping on request:** If a referee, member of the Technical or Organizational committee, an Executive or Trustee of the federation tells the team to stop the robot, there will be no discussion and the robot must be stopped *immediately*.
3. **Penalties:** If the team does not comply, the team and its members will be excluded from the ongoing competition immediately by a decision of the RoboCup@Home *Technical Committee* (TC). Furthermore, the team and its members may be banned from future competitions for a period not less than a year by a decision of the RoboCup Federation Trustee Board.

3.7.2 Maximum number of team members

1. **Regular Tests:** During a regular test, the maximum number of team members allowed inside the *Arena* is *one* (1). Exceptions are tests that explicitly require volunteer assistance.
2. **Setup:** During the setup of a test, the number of team members inside the *Arena* is not limited.
3. **Final:** During the *Final*, the number of team members inside the *Arena* is not limited.
4. **Moderation:** During a regular test, one team member *must* be available to host and comment the test (see Section 3.7.13).

3.7.3 Fair play

Fair Play and cooperative behavior is expected from all teams during the entire competition, in particular:

- while evaluating other teams,

- while refereeing, and
- when having to interact with other teams' robots.

This also includes:

- not trying to cheat (e.g., pretending autonomous behavior where there is none),
- not trying to exploit the rules (e.g., not trying to solve the task but trying to score), and
- not trying to make other robots fail on purpose.
- not modifying robots in standard platforms.

Disregard of this rule can lead to penalties in the form of negative scores, disqualification for a test, or even for the entire competition.

3.7.4 Expected Robot's Behavior

Unless stated otherwise, it is expected that the robot always behave and react in the same way a polite and friendly human being would do. This applies also to how robots try solve the assigned task. As rule of thumb, one may ask any non-scientist how she would solve the task.

Please consider that average users will not know the specific procedure to operate a robot. Hence, interaction should be as with any other human being.

3.7.5 Robot Autonomy and Remote Control

1. **No touching:** During a test, the participants are not allowed to make contact with the robot(s), unless it is in a "natural" way and required by the task.
2. **Natural interaction:** The only allowed means to interact with the robot(s) are gestures and speech.
3. **Natural commands:** Anything that resembles direct control is forbidden.
4. **Remote Control:** Remotely controlling the robot(s) is strictly prohibited. This also includes pressing buttons, or influencing sensors on purpose.
5. **Penalties:** Disregard of these rules will lead to disqualification for a test or for the entire competition.

3.7.6 Collisions

1. **Touching:** Gently *touching* objects is tolerated but unadvised. However, robots are not allowed to crash with something. The "safety first" rule (Section 3.7.1) overrides any other rule.
2. **Major collisions:** If a robot crushes into something during a test, the robot is immediately stopped. Additional penalties may apply.
3. **Functional touching:** Robots are allowed to apply pressure on objects, push away furniture and, in general, interact with the environment using structural parts other than their manipulators. This is known as *functional touching* (.). However, the robot must clearly announce the collision-like interaction and kindly request not being stopped.
Remark: Referees can (and will) immediately stop a robot in case or suspicion of *dangerous* behavior.
4. **Robot-Robot avoidance:** If two robots encounter each other, they both have to actively try to avoid the other robot.

- 4.1. A robot which is not going for a different route within a reasonable amount of time (e.g., 30s) is removed.
- 4.2. A non-moving robot blocking the path of another robot for longer than a reasonable amount of time (e.g., 30s) is removed.

3.7.7 Removal of robots

Robots not obeying the rules are stopped and removed from the *Arena*.

1. It is the decision of the referees and the TC member monitoring the test if and when to remove a robot.
2. When told to do so by the referees or the TC member monitoring the test, the team must immediately stop the robot, and remove it from the *Arena* without disturbing the ongoing test.

3.7.8 Start signal

The default *start signal* (unless stated otherwise) is *door opening*. Other start signals are allowed but must be authorized by the *Technical Committee* (TC) during the Robot Inspection (see Section 4.4).

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 (not a team member) 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. It must be a physical button on the robot (e.g., a dedicated one or releasing the eStop).
 - 2.2. It is allowed to use the robot's contact/pressure sensors (e.g., pushing the head or an arm joint).
 - 2.3. Using a start button needs to be announced to the referees before the test starts.
 - 2.4. There may be penalties for using a start button in some tests
3. **Ad-hoc start signal:** Other means of triggering robot to action are allowed but must be approved by the *Technical Committee* (TC) during the Robot Inspection (see Section 4.4). These include:
 - QR Codes
 - Verbal instructions
 - Custom HRI interfaces (apps, software, etc.)

Remark: There may be penalties for using Ad-hoc start signals in some tests. The use of mouses, keyboards, and devices attached to ECRA computers is strictly forbidden.

3.7.9 Entering and leaving the *Arena*

1. **Start position:** Unless stated otherwise, the robot starts outside of the *Arena*.
2. **Entering:** The robot must autonomously enter the *Arena*.
3. **Success:** The robot is said to *have entered* when the door used to enter can be closed again, and the robot is not blocking the passage.

3.7.10 Gestures

Hand gestures may be used to control the robot in the following way:

1. **Definition:** The teams define the hand gestures by themselves.
2. **Approval:** Gestures need to be approved by the referees and TC member monitoring the test. Gestures should not involve more than the movement of both arms. This includes, e.g., expressions of sign language or pointing gestures.
3. **Instructing operators:** It is the responsibility of the team to instruct operators.
 - 3.1. The team may only instruct the operator when told to so by a referee.
 - 3.2. The team may only instruct the operator in the presence of a referee.
 - 3.3. The team may only instruct the robot for as long as allowed by the referee.
 - 3.4. When the robot has to instruct the operator, it is the robot that instructs the operator and *not* the team. The team is not allowed to additionally guide the operator, e.g., tell the operator to come closer, speak louder, or to repeat a command.
 - 3.5. The robot is allowed to instruct the operator at any time.
4. **Receiving gestures:** Unless stated otherwise, it is not allowed to use a speech command to set the robot into a special mode for receiving gestures.

3.7.11 Referees

All tests are monitored by a referee and one member of the *Technical Committee* (TC). The following rules apply:

1. **Selection:**
 - Referees are chosen by EC/TC/OC.
 - Referees are announced together with the schedule for the test slot.
2. **Not showing up:** Not showing up for refereeing (on time) will result in a penalty (see Section 3.9.2).
3. **TC monitoring:** A TC member acts as main referee.
4. **Referee instructions:** Right before each test, referee instructions are conducted by the TC. The referees for all slots need to be present at the *Arena* where the referee instructions are taking place. When and where referee instructions are taking place is announced together with the schedule for the slots.

3.7.12 Operators

Unless stated otherwise, robots are operated by the referee or by a person selected by the referee. If the robot fails to understand the default operator, the team may request the use of a custom operator. Penalty may apply when using a custom operator.

3.7.13 Moderator

The LOC is responsible of 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).

Responsibilities: The moderators have to:

- Do **NOT interfere** with the performance
- Explain the tasks being performed
- Comment on the performance of the competitor
- Follow the instructions of the referee.

Not showing up: Not showing up for moderation (on time) will result in a penalty (see Section 3.9.2).

3.7.14 Time limits

1. **Stage I:** Unless stated otherwise, the time limit for each test in *Stage I* is *5 minutes*.
2. **Stage II:** Unless stated otherwise, the time limit for each test in *Stage II* is *10 minutes*.
3. **Inactivity:** Robots are not allowed to stand still or get stuck into endless loops. A robot not progressing in the task execution (and obviously not trying to), is considered as inactive. Robots must be removed after 30 seconds of inactivity.
4. **Requesting time:** A robot (not the team) can request referees to make exception from the 30-seconds inactivity time limit. In its request, the robot must clearly state for how long it will be performing a time-consuming process (e.g., 60 seconds). This time cannot exceed 3 minutes and cannot be used more than once per test.
5. **Setup time:** Unless stated otherwise, there is no setup time. Robots need to be ready to enter the *Arena* no later than one minute after the door has been closed to the former team.
6. **Time-up:** When the time is up, the team must immediately remove their robot(s) from the *Arena*. No more additional score will be given.
7. **Show must go on:** On special cases, the referee may let the robot continue the test for demonstration purposes, but no additional points will be scored.

3.7.15 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 slot 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 allotted 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, starting when the referee announces the 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: Bypassing Features With Human Help

Because the Show Must Go On

Robots can't score unless they accomplish the main goal of a task. However, in many real-life situations, a minor malfunction may prevent the robot from accomplishing a task. To prevent this situation, while fostering awareness and human-robot interaction, robots are allowed to request human assistance during a test.

3.8.1 Procedure

The procedure to request human assistance while solving a task is as follows:

1. **Request help:** The robot must indicate loud and clear that it requires human assistance. It must be clearly stated:
 - The nature of the assistance
 - The particular goal or desired result
 - How the action must be carried out (when necessary)
 - 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.

Example

In the following example, a robot has to clean the table, but is unable to grasp the spoon.

R: I am sorry, but the spoon is too small for me to take.
 Could you please help me with it?
 Please say "robot yes" or "robot no" to confirm.

H: *Robot, yes!*

R: Thank you! Please follow my instructions.
 Please take the purple spoon from the table. It is on my left.

H: (Referee takes green fork)

R: You took the wrong object.
 Please take the purple spoon from the table. It is on my left.

H: (Referee takes purple spoon)

R: I saw you took the spoon.
 Would you be so kind to follow me to the kitchen?
 Please keep the spoon visible in front of you so I can track you. Thank you!

R: You can stop following me now.
 As you can see, the dishwasher is already open.
 Please place the spoon in the gray basket on the lower tray.

R: Lovely! Thanks for your help.
 I'll let you know if I need further assistance.

3.8.2 Scoring

There is no limit in the amount of times a robot can request human assistance, but score reduction applies every time it is requested.

1. **Partial execution:** A reduction of 10% of the maximum attainable score is applied when the robot request a partial solution (e.g. pointing to the person the robot is looking for or placing an object within grasping distance). The referee decides whether the requested action is simple enough to corresponds to a partial execution or not.
2. **Full awareness:** A reduction of 20% of the maximum attainable score is applied when the robot is able to track and supervise activity, detecting possible, and when the requested action has been completed.
3. **No awareness:** A reduction of 30% of the maximum attainable score is applied when the robot has to be told when the requested action has been completed.
4. **Bonuses:** No bonus points can be scored when the robot requests help to solve part of a task that normally would grant a bonus.
5. **Score reduction overlap:** The score reduction for multiple requests of the same kind do not stack, but overlap. The total reduction applied correspond to the worse execution (higher reduction of all akin help requests). This means, a robot won't be reduced again for requesting help to transport a second object, but a second reduction will apply when the robot asks for a door to be opened.
6. **Allowed types of assistance:** The types of assistance allowed in a given task are specified in the respective task description. It should be noted that only the assistance types explicitly mentioned in a task description are actually allowed in a task; other types of assistance are not allowed and will nullify the obtained points for the part of the task in which they are applied. For instance, if a task focused on manipulation does not explicitly mention a Deus Ex Machina penalty for instructing a person to perform a manipulation activity, it should not be assumed that this is a loophole that can be exploited.

3.8.3 Bypassing Automatic Speech Recognition

Giving commands to the robot is essential in many tests. When the robot is not able to receive spoken commands, teams are allowed to provide means to bypass ASR via an Alternative method for HRI (see Section 3.8.3). Nonetheless, Automatic Speech Recognition is preferred.

The following rules apply in addition to the ones specified in section Section 3.8.2

1. **ASR with Default Operator:** No score reduction. The command is given by the human operator who must speak (not shout) loud and clear. The *default operator* may repeat the command up to three times.
2. **ASR with Custom Operator:** A reduction of 10% of the maximum attainable score is applied when a *custom operator* is requested. The Team Leader chooses a person who gives the command *exactly as instructed by the referee*.
3. **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.
4. **QR Codes:** A reduction of 30% of the maximum attainable score is applied when a QR code is used to instruct the robot.
5. **Alternative Input Method:** A reduction of up to 30% of the maximum attainable score is applied when a *alternative HRI interface*, is used to instruct the robot. Alternative HRI interfaces (see Section 3.8.3) must be previously approved by the TC during the Robot Inspection (see Section 4.4).

Alternative interfaces for HRI

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 to use and self-explanatory:** a manual should not be needed. Teams are not allowed to explain how to interface with the robot.
- **Effortless use:** Must be as easy to use as uttering a command.
- **Is smart and preemptive:** The interface adapts to the user input, displaying only the options that make sense or that the robot can actually perform.
- Exploits the best of the device being used (eg. touch screen, display area, speakers, etc.)

Preferably, the alternative HRI must be also adapted to the user. Consider localization (with English as the default), but also potential users of service robots at their home. For example: elderly people and people with physical disabilities.

Award: The best alternative is awarded the Best Human-Robot Interface award (Section 1.7.2).

3.9 Special penalties and bonuses

3.9.1 Penalty for not attending

1. **Automatic schedule:** All teams are automatically scheduled for all tests.
2. **Announcement:** If a team cannot participate in a test (for any reason), the team leader has to announce this to the OC at least *60 minutes* before the test slot begins.
3. **Penalties:** A team that is not present at the start position when their scheduled test starts, the team is not allowed to participate in the test anymore. If the team has not announced that it is not going to participate, it gets a penalty of *250 points*.

3.9.2 Extraordinary penalties

1. **Penalty for cheating:** If a team member is found cheating or breaking the Fair Play rule (see Section 3.7.3), the team will be automatically disqualified of the running test, and a penalty of *500 points* is handed out. The *Technical Committee* (TC) may also disqualify the team for the entire competition.
2. **Penalty for faking robots:** 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. **Extra penalty for collision:** In case of major, (grossly) negligent collisions the *Technical Committee* (TC) may disqualify the team for a test (the team receives *0 points*), or for the entire competition.
4. **Not showing up as referee or jury member:** If a team does not provide a referee or jury member (being at the *Arena* on time), the team receives a penalty of *250 points*, and will be remembered for qualification decisions in future competitions.
Jury members missing a performance to evaluate are excluded from the jury, and the team is disqualified from the test (receives *0 points*).

5. **Modifying or altering standard platform robots:** If any unauthorized modification is found on a Standard Platform League robot, the responsible team will be immediately disqualified for the entire competition while also receiving a penalty of *500 points* in the overall score. This behavior will be remembered for qualification decisions in future competitions.

3.9.3 Bonus for outstanding performance

1. For every regular test in *Stage I* and *Stage II*, the @Home *Technical Committee* (TC) can decide to give an extra bonus for *outstanding performance* of up to 10% of the maximum test score.
2. This is to reward teams that do more than what is needed to solely score points in a test but show innovative and general approaches to enhance the scope of @Home.
3. If a team thinks that it deserves this bonus, it should announce (and briefly explain) this to the *Technical Committee* (TC) beforehand.
4. It is the decision of the *Technical Committee* (TC) if (and to which degree) the bonus score is granted.

3.10 Open Challenge

On the first two competition days after the end of the regular test blocks, teams will have an opportunity to present an *Open Challenge* in which they 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 the *Setup Days*.
2. **Time:** Each team gets a 10 minute time slot for the *Open Challenge*; of these, 8 minutes are for presenting and 2 minutes are 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; in particular, the *Open Challenge* should not be turned into a pure academic lecture.
5. **Leagues:** Ideally, the open challenges of all @HOME leagues will be scheduled consecutively so that everyone has an opportunity to see all demonstrations; however, in case more than 12 participants across the leagues register for the *Open Challenge*, each league will hold their *Open Challenge* concurrently.
6. **Award:** The *Open Challenge* does not contribute any points towards the official competition score, but participating teams are eligible to receive the *Best Open Challenge Award* (see 1.7.4).

3.11 Manipulation Challenge

In cooperation with MathWorks and together with the RoboCup@Work league, an additional technical manipulation challenge is offered to @HOME teams starting from 2022. The objective is to use a manipulator, programmed in MATLAB and Simulink, for sorting objects that lie on a table into separate bins near the manipulator. This year, the challenge is simulation-based, using Gazebo as a simulation environment. The overall winner of the challenge will receive a research grant of up to \$5,000; all other participants will receive a certificate of participation.

Teams already registered for RoboCup@Home can participate in the challenge without any additional cost. Note that the challenge does not contribute points towards the overall score of the @Home competition; however, the best @Home team that participates in the challenge may receive a separate certificate for the achievement (even if they are not the overall winner of the challenge). More details about the challenge are provided on the official page: arm.robocup.org. This includes information about the registration procedure, the competition timeline, and, most importantly, the rules of the challenge.

Chapter 4

Setup and Preparation

Prior to the RoboCup@Home competition, all arriving teams will have an opportunity to set up their robots and prepare for the competition in a *Setup & Preparation* phase. This phase is scheduled to start on the first day of the competition, namely when the venue opens and the teams arrive. During the *Setup Days*, teams can assemble and test their robots. On the last setup day, a *Welcome Reception* will be held. To foster the knowledge exchange between teams a conference-like *Poster Session* takes place during the reception. Additionally, all teams have to get their robots inspected by members of the TC to be allowed to participate in the competition.

Regular tests are not conducted during the setup & preparation phase. The competition starts with *Stage I* (see Section 5).

Table 4.1: Stage System and Schedule per League (distribution of tests and stages over days may vary)

Setup & Preparation	<i>Stage I</i>	<i>Stage II</i>	<i>Finals</i>
	$\xrightarrow{\text{advance}}$ All teams that passed Inspection	$\xrightarrow{\text{advance}}$ Best 10 (< 6) or best 50% (≥ 12)	$\xrightarrow{\text{advance}}$ Best 2 teams

4.1 General Setup

Depending on the schedule, the *Setup & Preparation* phase lasts for one or two days.

1. **Start:** The *Setup & Preparation* starts when the venue opens for the first time.
2. **Intention:** During the *Setup & Preparation*, teams arrive, bring or receive their robots, and assemble and test them.
3. **Tables:** The local organization will set up and randomly assign team tables.
4. **Groups:** Depending on the number of teams, the *organizing committee* (OC) may form multiple groups of teams (usually two) for the first (and second stage). The OC will assign teams to groups and announce the assignment to the teams.
5. **Arena:** The *Arena* is available to all teams during the *Setup & Preparation*. The OC may schedule special test or mapping slots in which *Arena* access is limited to one or more teams exclusively (all teams get slots). Note, however, that the *Arena* may not yet be complete and that the last work is conducted in the *Arena* during the *Setup Days*.

6. **Objects:** The delegation of EC, TC, OC and local organizers will buy the objects (see Section 3.3.5). Note, however, that the objects may not be available at all times and not from the beginning of the *Setup & Preparation*.

4.2 Welcome Reception

Since Eindhoven 2013, RoboCup@Home holds an own *Welcome Reception* in addition to the official opening ceremony. During the *Welcome Reception*, a *Poster Session* is held in which teams present their research focus and latest results (see Section 4.3).

1. **Time:** The *Welcome Reception* is held in the evening of the last setup day.
2. **Place:** The *Welcome Reception* takes place in the @Home *Arena* and/or in the @HOME team area.
3. **Snacks & drinks:** During the *Welcome Reception*, snacks and beverages (beers, sodas, etc.) are served.
4. **Organization:** It is the responsibility of the OC and the local organizers to organize the *Welcome Reception* and *Poster Session*, including:
 - 4.1. organizing poster stands (one per team) or alternatives for presenting the posters,
 - 4.2. organizing snacks and drinks, and
 - 4.3. inviting officials, sponsors, the local organization, and the trustees of the RoboCup Federation to the event.
5. **Poster presentation:** During the *Welcome Reception*, the teams give a poster presentation on their research focus, recent results, and their scientific contribution. Both the poster and the teaser talk are evaluated by a jury (see Section 4.3).

4.3 Poster Teaser Session

Before the *Welcome Reception* and *Poster Session*, a *Poster Teaser Session* is held. In this teaser session, each team can give a short presentation of their research and the poster being presented at the poster session.

4.3.1 Poster teaser session

1. **Presentation:** Each team has a maximum of three minutes to give a short presentation of their poster.
2. **Time:** The *Poster Teaser Session* is to be held before the *Welcome Reception* and *Poster Session* (see Section 4.2).
3. **Place:** The *Poster Session* may be held in or around the *Arena*, but should not interfere with the *Robot Inspection* (see Section 4.4).
4. **Evaluation:** The teaser and poster presentations are evaluated by a jury consisting of members of the other teams. Each team has to provide one person (preferably the team-leader) to follow and evaluate the entire *Poster Teaser Session* and the *Poster Session*.
5. **Criteria:** For each of the following evaluation criteria, a maximum of 10 points is given per jury member:

- 5.1. Novelty and scientific contribution
- 5.2. Relevance for RoboCup@Home
- 5.3. Presentation (quality of poster, teaser talk, and discussion during the *Poster Session*)
6. **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:

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

7. **Sheet collection:** The evaluation sheets are collected by the OC at a later time (announced beforehand by the OC), allowing teams to continue knowledge exchange during the first days of the competition (*Stage I*).
8. **OC Instructions:**
 - Prepare and distribute evaluation sheets before the *Poster Teaser Session*.
 - Collect the evaluation sheets.
 - Organize and manage the poster teaser presentations and the *Poster Session*.

4.4 Robot Inspection

Safety is the most important issue when interacting with humans and operating in the same physical workspace. Because of this, all participating robots are inspected before participating in RoboCup@Home. Every team needs to get their robot(s) inspected and approved so that they can participate in the competition.

1. **Procedure:** The *Robot Inspection* is conducted like a regular test, namely it starts with opening of the arena door (see Section 3.7.8). One team after another (and one robot after another) has to enter the *Arena* through a designated entrance door, move to the *Inspection Point*, and leave the arena through the designated exit door. In between entering and leaving, the robot is inspected by the *technical committee* (TC).
2. **Checked aspects:** During the *Robot Inspection*, each robot is checked for compliance with the competition rules (see Section 3.4), in particular:
 - emergency button(s)
 - collision avoidance (a TC member steps in front of the robot)
 - voice of the robot (it must be loud and clear)
 - custom containers (bowl, tray, etc.)
 - external devices (including wireless network), if any
 - Alternative human-robot interfaces (see Section 3.8.3).
 - **Standard Platform robots**
 - no modifications have been made
 - specification of the *Official Standard Laptop* (OSL) (if required)
 - **Open Platform robots**
 - robot speed and dimension
 - start button (if the team requires it)

- robot speaker system (plug for RF transmission)
 - other safety issues (duct tape, hanging cables, sharp edges etc.)
3. **Re-inspection:** If the robot is not approved in the inspection, it is the responsibility of the team to get the approval at a later point. Robots are not allowed to participate in any test before passing the *Robot Inspection*.
 4. **Time limit:** The robot inspection is interrupted after three minutes (per robot). When told so by the TC — in case of time interrupt or failure — the team has to move the robot out of the *Arena* through the designated exit door.
 5. **Appearance Evaluation:** In addition to the inspection, the TC evaluates the appearance of the robots. Robots are expected to look nice (no duct tape, no cables hanging loose etc.). In case of objection, the TC may penalize the team with a penalty of maximum 50 points.
 6. **Accompanying team member:** Each robot is accompanied by only one team member (the team leader is advised).
 7. **OC instructions (at least 2h before the *Robot Inspection*):**
 - Announce the entry and exit doors.
 - Announce the location of the *Inspection Point* in the *Arena*.
 - Specify and announce where and when the poster teaser and the poster presentation session take place.

Chapter 5

Tests in Stage I

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5.1 Carry My Luggage

The robot helps the operator to carry some luggage to a car which is parked outside.

Main Goal: The robot helps the operator to carry a bag to a car parked outside.

Optional Goals:

1. Re-entering the arena
2. Following the queue on the way back to the arena

Focus

Person following, navigation in unmapped environments, social navigation.

Setup

- **Locations:**
 - The test takes place both inside and outside the *Arena*.
 - The robot starts at a predefined location in the living room.
- **People:** The operator is standing in front of the robot and is pointing at the bag to be carried outside.
- **Objects:** At least two bags are placed near the operator (within a 2m distance and visible to the robot).

Procedure

1. **Picking up the bag:** The robot picks up the bag pointed at by the operator.
2. **Following the operator:** The robot should inform the operator when it is ready to follow them. The operator walks naturally towards the car; after reaching the car, the operator takes the bag back and thanks the robot.
3. **Obstacles:** The robot will face 4 obstacles along its way (in arbitrary order): (a) a small object on the ground, (b) a hard-to-see object, (c) a crowd of people obstructing the path outside, and (d) a small area blocked using retractable barriers.
4. **Optional goals:**
 - 4.1. **Re-entering the arena:** The robot returns to the arena, going back in through the entrance.
 - 4.2. **Following the queue:** After the robot has reached the car, a few of the people that formed the crowd obstructing the robot return to the arena in a queue. The robot can decide to join the queue on its way back to the arena, in a manner that appears natural to the people in the queue.

Additional Rules and Remarks

1. **Car location:** There is no real car outside; instead, a fixed location outside the *Arena* is designated as a car location.
2. **Reaching the car:** The robot can reach the car location only by following the operator (the location is unknown before the test).

3. **Deus ex Machina:** Score reductions for human assistance are applied in case the robot loses the operator, and needs to find them again through:
 - 3.1. Natural interaction (e.g., waving and calling)
 - 3.2. Unnatural interaction (e.g., raising both hands and jumping)
 - 3.3. Touching the robot (e.g., pulling the robot's hand)

Referee Instructions

The referees need to:

- Select one volunteer to act as the operator.
- Select three to four people to obstruct the robot's path outside and form the queue on the way back to the arena.
- Choose positions for the bags and assign a bag to the operator.
- Choose the order of the obstacles that the robot will face outside while following the operator.
- Designate a location outside as a car location.
- Designate a location for the queue to form returning into the arena. The queue is composed of the same people that form the crowd.
- Mind the robot when it goes outside the *Arena*.

OC Instructions

2h before test:

- Select and announce the robot's starting point.
- Select which bags will be used in the test.

Score Sheet

The maximum time for this test is 5 minutes.

Action	Score
<i>Main Goal</i>	
Picking up the correct bag	100
Following the person to the car	300
Avoiding the crowd of people obstructing the path	50
Avoiding the small object on the ground	50
Avoiding the hard-to-see object	50
Avoiding the area blocked with retractable barriers	50
<i>Bonus rewards</i>	
Re-entering the arena	100
Joining and staying in the queue on the way to the arena	300
<i>Regular Penalties</i>	
Dropping the bag	50
<i>Deus Ex Machina Penalties</i>	
Rediscovering the operator by natural interaction	-50
Rediscovering the operator by unnatural interaction	-100
Rediscovering the operator by direct contact	-200
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	1050

5.2 General Purpose Service Robot

Similar to a smart speaker, the robot is asked to execute arbitrary commands requested by an operator.

Note: Due to this task's more open-ended nature, the maximum possible score is higher than the scores of the other *Stage I* tasks.

Main Goal: Execute 3 commands requested by the operator.

Optional Goals:

1. Understand a command given by a non-expert operator.

Focus

Task planning, object/people detection and recognition, object feature recognition, object manipulation

Setup

- **Locations:**

- **Task location:** The task takes place inside the *Arena*, but some commands may require the robot to go out. The *Arena* is in its nominal state for this task.
- **Start location:** The robot starts outside the *Arena*. When the door opens, the robot moves towards the *Instruction Point*.
- **Instruction point:** At the beginning of the test, as well as after finishing the first and second command, the robot moves to the *Instruction Point*.

- **People:**

- **Operators:** A *Professional Operator* (the referee) commands the robot to execute a task. Optionally, commands can be issued by a *Non-Expert Operator*, i.e. a person from the audience with no robotics background. In this case, the referee gives the command to the non-expert operator, who will then issue it to the robot (rephrasing is allowed). If the robot consistently fails to understand the non-expert operator (e.g. after two retries), teams can default to a custom operator.

Procedure

1. **Instruction point:** Two hours before the test, the referees announce the location of the *Instruction Point*.
2. **Test start:** The robot moves to the *Instruction Point* when the arena door is open.
3. **Command execution:** The operator instructs the robot to execute a command and the robot performs the task.
4. **Back to the instruction point:** The robot goes back to the *Instruction Point* and waits for the next command.

Additional Rules and Remarks

1. **Partial scoring:** The main task allows partial scoring (per *completed* command).
2. **Command generator:** Tasks will be generated using the official *GPSR Command Generator*¹.
3. **Non-expert operators:** Referees are not allowed to instruct non-expert operators on how to operate the robot. Teams attempting to instruct or bias the operator will be disqualified from the task.
4. **Deus ex Machina:** The scores are reduced if human assistance is received, in particular for:
 - using a custom operator
 - bypassing speech recognition by using an alternative HRI
 - receiving human assistance to accomplish a task (score reduction is applied consistent with the other tasks in this rulebook)
 - instructing a human assistant to perform the whole task

Referee Instructions

- Provide the commands to the operators.

OC Instructions

2h before the test:

- Generate the robot commands (don't reveal them to the teams!).
- Announce the location of the instruction point.
- Recruit volunteers to assist during the test.

During the test:

- Rearrange the arena so that it is in its nominal condition before each command.

Score Sheet

The maximum time for this test is 5 minutes.

¹<https://github.com/kyordhel/GPSRCmdGen>

Action	Score
<i>Main Goal</i>	
Executing the task associated with each command	3×400
<i>Bonus Rewards</i>	
Understanding a command given by a non-expert operator	3×100
<i>Deus Ex Machina Penalties</i>	
Using a custom operator	3×-50
Bypassing speech recognition	3×-50
Instructing a human to perform the task	3×-400
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	1500

5.3 Receptionist

Description

The robot has to take two new guests to the living room to introduce them and offer a free place to sit.

Main goal: Introduce and usher two newcomers to a party and maintain appropriate gaze direction (at person, direction of navigation).

Optional goals:

1. Open the entrance door for each arriving guest.
2. Describe the first guest for the second guest.

Focus

System Integration, Human-Robot Interaction, Person Detection, Person Recognition

Setup

- **Location:**
 - The test takes place in the living room.
 - 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.
- **People:**
 - **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 ring the bell if the door is closed. Guests have to be guided to the living room to be introduced. Each of the guest will arrive separately. The sound of the bell will be provided to teams during setup period before competition.

Procedure

- **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.
- **Looking at person/direction of navigation:** During verbal interactions and descriptions of people, robot looks at the conversational partner. Robot can point at the person being introduce/described or alternate gaze between two people. During navigation robot looks in the direction where it is going. Persistently gazing towards unrelated person or incorrect direction while moving during the task deducts 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.

Instructions

To Referee

The referees need to:

- Assign name and drink to 3 volunteers.
- Arrange (and re-arrange) people in the living room.
- Open the door when requested by the robot.

To OC

During setup day:

- Provide the doorbell sound.

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
<i>Main Goal</i>	
Introduce a new guest to every other guest and offer a seat	2×250
Look at the person talking	50
Look at the person being described	50
Look in the direction of navigation	50
Continue with wrong name or drink	2×-50
Persistent inappropriate gaze - away from conversational partner	2×-50
Persistent gaze not in the direction of the navigation while moving	-50
<i>Bonus Rewards</i>	
Open the entrance door for a guest	2×100
Describe the first guest to the second guest	150
<i>Deus Ex Machina</i>	
Alternative HRI	2×-75
Not recognizing people	2×-200
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Total Score (excluding special penalties & standard bonuses)	1000

5.4 Serve Breakfast

The robot has to set a table for breakfast for one person and prepare cereal for them.

Main Goal: Place breakfast items on a table (bowl, spoon, cereal box, and milk carton) and prepare cereal.

Optional Goals:

1. Pour milk into the bowl
2. Place the spoon next to the bowl

Focus

Object perception, manipulation, and task planning.

Setup

- **Locations:**
 - **Start location:** Before the test, the robot waits outside the *Arena* and navigates to the kitchen when the door is open.
 - **Test location:** The test itself takes place in the kitchen.
- **People:**
 - No people are involved in the test, unless the robot requires human assistance.
- **Furniture:**
 - **Table:** The robot serves breakfast on any table or flat surface in the kitchen (the team is free to choose this location).
 - **Chairs:** Chairs may be placed around the kitchen table and won't be removed.
 - **Doors:** The robot does not need to open any doors for finding the breakfast items.
- **Objects:**
 - All objects used in the test are in their predefined locations when the test starts.

Procedure

1. **Table selection:** Half an hour before the test starts, the team informs the referees about the surface that will be used as a table.
2. **Test start:** The robot moves to the kitchen when the arena door is open.
3. **Serving breakfast:** To serve breakfast, the robot has to place breakfast items on a table (bowl, spoon, cereal box, and milk carton).
4. **Pouring cereal:** After placing the breakfast items on the table, the robot should pour cereal into the bowl.
5. **Optional goals:**
 - **Pouring milk:** After pouring cereal, the robot pours milk into the bowl in order to fully prepare the breakfast.

- **Placing the spoon next to the bowl:** In principle, the spoon can be placed anywhere on the table, but placing it next to the bowl is desired so that it is easily reachable by a person.

Additional Rules and Remarks

1. **Safe placing:** Objects must be placed with care, namely the robot should place rather than throw or drop objects.
2. **Deus ex Machina:** The scores are reduced if human assistance is received, in particular for:
 - pointing to an object or telling to the robot where an object is or where to place it
 - handing an object over to the robot
 - having a human place objects on the table
 - having a human pour cereal into the bowl

OC Instructions

During the *Setup Days*:

- Provide official cutlery and tableware for training.

Referee Instructions

The referee needs to:

- Remove all objects from the table.
- Place all objects in their default locations.

Score sheet

The maximum time for this test is 5 minutes.

Action	Score
<i>Main Goal</i>	
Picking up breakfast items for transportation to the table	4×15
Placing breakfast items on the table	4×60
Pouring cereal into the bowl	300
<i>Bonus Rewards</i>	
Pouring milk into the bowl	300
Placing a spoon next to the bowl	100
<i>Regular Penalties</i>	
Throwing or dropping an object on the table	4×-30
Spilling cereal while pouring	-100
Spilling milk while pouring	-150
<i>Deus Ex Machina Penalties</i>	
Pointing at an object	4×-25
Handing an object over to the robot	4×-50
A human placing an object on the table	4×-75
A human pouring cereal in the bowl	-300
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
<hr/>	
Total Score (excluding special penalties & standard bonuses)	1000

5.5 Storing Groceries

The robot stores groceries into a cabinet with shelves. Objects are sorted on the shelves based on similarity, for instance an apple is stored next to other fruits.

Main goal: Move five objects from a table to the cabinet, grouping them by category or similarity.

Optional goals:

1. Opening the cabinet door
2. Moving a *tiny* object
3. Moving a *heavy* object

Focus

Object detection and recognition, object feature recognition, object manipulation.

Setup

- **Locations:**
 - **Start location:** Before the test, the robot waits outside the *Arena* and navigates to the testing area when the door is open.
 - **Test location:** The testing area has a cabinet and a table nearby.
- **People:**
 - No people are involved in the test, unless the robot requires human assistance.
- **Furniture:**
 - **Table:** The table has 5–10 objects placed on it and the robot can choose which ones to grasp and in what order. On small tables, objects will be added as the robot frees up space.
 - **Cabinet:** The cabinet contains objects arranged in groups — either by category or likeliness — on different shelves.
 - **Cabinet door:** The cabinet door is open by default, but 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 this and request the referee to open it.
- **Objects:**
 - **Table objects:** The object on the table are arranged arbitrarily.
 - **Cabinet objects:** Some of the objects are placed behind the cabinet door and cannot be accessed unless the door is open.

Procedure

1. **Table location:** Two hours before the test, the referees announce the table and cabinet that will be used in the test, as well as a rough location of the table.

2. **Cabinet door; heavy and/or tiny object:** Half an hour before the test, the team informs the referees:
 - whether the cabinet door should be closed
 - whether a heavy and/or a tiny object should be used in the test
3. **Test start:** The robot moves to the testing area when the arena door is open.
4. **Storing groceries:** After identifying the table (and optionally opening the cabinet door), the robot moves the objects from the table to the cabinet.

Additional rules and remarks

1. **Table:** The table's rough location will be announced beforehand, having its position to the left, right, or behind the robot.
2. **Incorrect categorization:** The score is reduced if an object is stored on the cabinet, but not on a shelf with similar objects; this reduction is applied per incorrectly stored object.
3. **New category:** Objects that do not semantically belong to any of the categories represented on the shelves should be grouped together on a new shelf.
4. **Deus Ex Machina:** The scores are reduced if human assistance is received, in particular for:
 - telling or pointing out to the robot where to place an object
 - moving an object instead of the robot

OC Instructions

2 hours before the test

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

Referee Instructions

The referee needs to:

- Place 5–10 objects on the table.
- Place objects in the cabinet, grouping them by category or likeliness.
- Open the door of the cabinet (unless the team wants it closed).

Score sheet

The maximum time for this test is 5 minutes.

Action	Score
<i>Main Goal</i>	
Picking up an object for transportation to the cabinet	5×30
Moving an object next to similar objects on the cabinet	5×90
<i>Bonus Rewards</i>	
Opening the cabinet door without human help	200
Moving a tiny object	100
Moving a heavy object	100
<i>Regular Penalties</i>	
Storing an object without categorizing it correctly	5×-60
<i>Deus Ex Machina Penalties</i>	
A human pointing at a target location	5×-30
A human handing an object over to the robot	5×-30
A human moving an object	5×-100
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
<hr/>	
Total Score (excluding special penalties & standard bonuses)	1000

Chapter 6

Tests in Stage II

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6.1 Clean the Table

The robot has to remove all dishes and cutlery from a table and place them into the dishwasher.

Main goals: All tableware and cutlery on the table is placed inside the dishwasher (five objects in total).

Optional goals:

1. Opening the dishwasher door
2. Pulling out the dishwasher rack
3. Placing the items in the dishwasher correctly
4. Placing a dishwasher tab inside the dishwasher

Focus

Object perception, manipulation in narrow spaces, and task planning.

Setup

• **Locations:**

- **Test location:** This test takes place in the kitchen.

• **People:**

- No people are involved in the test, unless the robot requires human assistance.

• **Furniture:**

- **Dining table:** A dining table is located close to the dishwasher.
- **Tray:** A plastic tray, which may have other tableware and cutlery placed inside, is located either on top of the dishwasher or on one of the racks. Objects can be placed either in the dishwasher rack or in the tray, based on the team's choice.

• **Objects:**

- **Table setting:** The table has a total of five objects disposed in a typical setting for a meal for one person. The object distribution is as follows:
 - * *Silverware:* Any two objects (fork, knife, or spoon).
 - * *Tableware:* Any three objects (except silverware), at least one of which is a dish.
- **Dishwasher tab:** The tab can be found at a location that is announced before the test and should be autonomously placed inside the tab slot in the dishwasher.

Procedure

1. **Dishwasher door and rack:** Half an hour before the test, the team informs the referees:
 - whether objects will be placed in the dishwasher rack or in the tray
 - whether the dishwasher door should be closed and, if the door is open, whether the rack should be pushed in
2. **Test start:** The robot moves to the kitchen when the arena door is open.

3. **Table clean up:** The robot cleans the table by putting all items that are on it in the dishwasher.

Additional Rules and Remarks

1. **Safe placing:** Objects must be placed with care, namely the robot should place rather than throw or drop objects.
2. **Dishwasher:** The team decides whether the robot will place the objects in the dishwasher's rack or in the plastic tray.
3. **Dishwasher door:** The dishwasher door is open and with the racks pulled out by default. The team leader can, however, request the dishwasher to be closed for bonus points. If the robot fails to open the door, it must clearly state this and request the referee to open the door.
4. **Correct item placement:** The items should be placed in the rack/tray correctly, namely in the location and in a manner as a person would put them.
5. **Deus ex Machina:** The scores are reduced if human assistance is received, in particular:
 - pointing to an object or telling the robot where an object is
 - handing an object over to the robot

OC Instructions

During the *Setup Days*:

- Provide official cutlery and tableware for training.

2 hours before the test:

- Announce the predefined location of the dishwasher tab.

Referee Instructions

The referee needs to:

- Place objects on the table.
- Place the plastic tray on the dishwasher or on a rack, as requested by the team.

Score sheet

The maximum time for this test is 10 minutes.

Action	Score
<i>Main Goal</i>	
Picking tableware and cutlery for transportation to the dishwasher	5×60
Placing the tableware and cutlery inside the dishwasher	5×180
<i>Bonus Rewards</i>	
Opening the dishwasher door	200
Pulling out the dishwasher rack	100
Placing an item correctly in the dishwasher	5×40
Placing the dishwasher tab inside the dishwasher	300
<i>Deus Ex Machina Penalties</i>	
Pointing at an object or telling the robot where an object is	5×-25
Handing an object over to the robot	5×-60
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
<hr/>	
Total Score (excluding special penalties & standard bonuses)	2000

6.2 Enhanced General Purpose Service Robot

Similar to a smart speaker, the robot is asked to execute arbitrary commands requested by an operator.

Note 1: Due to this task's more open-ended nature, the maximum possible score is higher than the scores of the other *Stage II* tasks.

Note 2: The commands in this task are more complex than in the GPSR task in *Stage I*.

Main Goal: Execute 3 commands requested by the operator.

Optional Goals:

1. Understand a command given by a non-expert operator.

Focus

Task planning, object/people detection and recognition, object feature recognition, object manipulation

Setup

1. Locations:

- **Test location:** The task takes place inside the *Arena*, but some commands may require the robot to go out. The *Arena* is in its nominal state for this test.
- **Start location:** The robot starts outside the *Arena*. When the door opens, the robot moves towards the *Instruction Point*.
- **Instruction point:** At the beginning of the test, as well as after finishing the first and second command, the robot moves to the *Instruction Point*.

2. People:

- **Operators:** A *Professional Operator* (the referee) commands the robot to execute a task. Optionally, commands can be issued by a *Non-Expert Operator*, i.e. a person from the audience with no robotics background. In this case, the referee gives the command to the non-expert operator, who will then issue it to the robot (rephrasing is allowed). If the robot consistently fails to understand the non-expert operator (e.g. after two retries), teams can default to a custom operator.

Procedure

1. **Instruction point:** Two hours before the test, the referees announce the location of the *Instruction Point*.
2. **Test start:** The robot moves to the *Instruction Point* when the arena door is open.
3. **Command execution:** The operator instructs the robot to execute a command and the robot performs the task.
4. **Back to the instruction point:** The robot goes back to the *Instruction Point* and waits for the next command.

Additional rules and remarks

1. **Partial scoring:** The main task allows partial scoring (per *completed* command).
2. **Command generator:** Tasks will be generated using the official *GPSR Command Generator*¹. Commands for EGPSR are either *Stage II* tasks, complex commands requiring to perform chains of subtasks in a sequence, or *incomplete* commands lacking relevant information to succeed.
3. **Non-expert operators:** A *Non-Expert Operator* receives a note-card with the summarized command from the referee and rephrases the command. Referees are not allowed to instruct non-expert operators on how to operate the robot. Teams attempting to instruct or bias the operator will be disqualified from the task.
4. **Custom operator fallback:** If the robot consistently fails to understand the professional or non-expert operator (three times in a row), the referee will request a custom operator to issue commands.
5. **Deus ex Machina:** The scores are reduced if human assistance is received, in particular for:
 - using a custom operator
 - bypassing speech recognition by using an alternative HRI
 - receiving human assistance to accomplish a task (score reduction is applied consistent with the other tasks in this rulebook)
 - instructing a human assistant to perform the whole task

Referee instructions

- Provide the note-cards to the operators.

OC instructions

2h before the test:

- Generate the robot commands (don't reveal them to the teams!).
- Announce the location of the instruction point.
- Recruit volunteers to assist during the test.

During the test:

- Rearrange the arena so that it is in its nominal condition before each command.

Score sheet

The maximum time for this test is 10 minutes.

¹<https://github.com/kyordhel/GPSRCmdGen>

Action	Score
<i>Main Goal</i>	
Executing the task associated with each command	3×800
<i>Bonus rewards</i>	
Understanding a command given by a non-expert operator	3×200
<i>Deus Ex Machina Penalties</i>	
Using a custom operator	3×-100
Bypassing speech recognition	3×-100
Instructing a human to perform the task	3×-500
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	3000

6.3 Restaurant

Description

The robot retrieves and serves orders to several customers in a real restaurant previously unknown to the robot.

Main goal: Detect calling or waving customer, reach a customer's table without prior guidance/training. Take and serve all orders.

Optional goal: Use an unattached tray to transport the order.

Focus

This task focuses on *Task planning*, *Online mapping*, *Navigation in unknown environments*, *Gesture detection*, *Verbal interaction* and *Object manipulation*.

Setup

- **Locations:**

- This task takes place in a real restaurant fully equipped and in business. When this is not possible, the test can be conducted in any place with the appropriate locations other than the *Arena*.
- The *Restaurant* location will remain secret until the start of the test.
- The robot starts next to the *Kitchen-bar*. It is a table located near the restaurant's kitchen.

- **People:**

- A *Professional Barman* (member of the TC) awaits at the other side of the *Kitchen-bar* for orders to be placed. The *Professional Barman* assists the robot on request.
- There may be real customers and waiters around.
- There are at least three tables occupied with professional customers (member of the OC/TC).
- There are at least two tables occupied with regular customers.
- Customers may call the robot any time, even simultaneously.

- **Furniture:** The furniture is not standardized and will be kept the same as the restaurant or place selected for the task.

- **Objects:**

- Objects to fulfill orders are located on the *Kitchen-bar*.
- Orders have between one and three objects randomly chosen.
- All edible/drinkable objects from the list of standard objects (see Section 3.3.5) are eligible to be part of the orders.

Procedure

1. The referee requests the team to move the robot to the start location.
2. The referee gives the start signal and starts the timer.
3. The team leaves the area after the start signal.

4. A TC member follows the robot ready to press the emergency stop button.
5. The robot detect calling or waving customer and reach a customer's table.
6. The robot take the customer's order, place the order, and deliver it.
7. **Optionally**, the robot can use an unattached tray to transport the order.

Additional rules and remarks

- **Remarks:**

- This test takes place in a public area. The robot is expected to not even slightly touch anyone or anything and is immediately stopped in case of danger.
- Since this task is performed outside the arena, the time limit may be longer than the others tasks.
- The availability of wireless, external computing devices, or electrical outlets can't be guaranteed. Assume unavailability.
- The robot interacts with the operators, not the team. The team is not allowed to instruct anyone. All instructions should be provided by the robot itself.
- The robot may use up to one minute to instruct the *Professional Barman*.
- The robot can request to be guided to a customer's table.
- The robot can choose to take several orders and place them later on, place an order and pick the next one while the former is being served, or dispatch one order at a time.
- The robot can either transport each object individually, or using a tray. All delivered objects must be placed on the customer's table.
- By default, the barman will place the order in a basket or tray for the robot to deliver it.
- Upon arrival to the restaurant, only the team leader is allowed next to the robot for watching and charging.
- 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.

- **Disqualification:**

- Touching the robot after the start signal.
- Tweaking, coding, debugging, or mapping the area in place.

Instructions:

To Referee

The referee needs to:

- Prepare orders for each client.

To OC

The OC needs to:

- **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

Maximum time:

15 minutes

Action	Score
<i>Regular Rewards</i>	
Detect calling or waving customer (per order).	2×100
Reach a customer's table without prior guidance/training (per order).	2×100
Take and serve an order.	2×600
<i>Bonus Rewards</i>	
Use an unattached tray to transport (per order).	2×200
<i>Regular Penalties</i>	
Not making eye-contact when taking an order (per order).	2×-100
<i>Deus ex Machina Penalties</i>	
Being guided to a table (per order).	2×-200
Bypassing manipulation (per object).	6×-100
Each object handover (per object).	6×-50
Being told/pointed where is a table/ <i>Kitchen-bar</i> (per order).	2×-25
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	2000

6.4 Smoothie Chef (Placeholder)

The home owner teaches the robot how to make a smoothie and the robot repeats the task on its own.

Main goal: The robot prepares a smoothie as taught, placing 3 fruits, milk, and sugar in a blender.

Optional goals:

1. Pouring *milk* without spilling
2. Pouring *sugar* without spilling

Focus

Action recognition and understanding, demonstration-based learning, object recognition and manipulation.

Setup

- **Locations:**
 - **Test location:** The test takes place in the kitchen.
 - **Start Location:** The robot starts the test at the kitchen counter.
 - **Operator location:** The operator is standing in front of the robot behind the counter.
- **People:**
 - **Operator:** The smoothie recipe is demonstrated by a *Professional Operator*. Teams can alternatively opt for a *Custom Operator*, which causes a score reduction.
- **Furniture:**
 - **Kitchen counter:** Either the kitchen table or counter can be used in this test.
- **Objects:**
 - **Ingredients:** On the counter, there are 6 *fruits*, one bottle of milk, and a bowl with sugar; all of these are standard objects (see Section 3.3.5).
 - **Sugar:** The sugar is contained in a bowl and must be served with a spoon. Any pourable solid can be used as sugar (such as actual sugar, but also muesli or cereal, for example).
 - **Milk:** Any liquid can be used as milk (such as actual milk, but also water or something else from the *Drinks* category).
 - **Official blender:** Unless a real blender is available (unlikely), teams can expect any large object (e.g., a plastic bottle, a glass, a bowl) from the list of standard objects (see Section 3.3.5) to be used as a blender.
 - **Smoothie recipe:** The recipe includes three out of six random fruits to be blended, one teaspoon of sugar, and a glass of milk. The score is reduced if an incorrect fruit (which has not been used in the demonstration) is placed inside the blender.

Procedure

1. **Test start:** The referee asks the team to move the robot to the start location and then gives a start signal.
2. **Smoothie demonstration:** The operator shows the robot how to prepare the smoothie.
3. **Smoothie preparation:** The robot prepares the smoothie as demonstrated.

Additional Rules and Remarks

1. **Deus ex Machina:** The scores are reduced if human assistance is received, in particular for:
 - starting the test in front of the kitchen counter
 - telling the robot which ingredient comes next (such as by pointing, naming, etc.)
 - handing an object over to the robot

OC Instructions

During the *Setup Days*:

- Announce which object will be used as a blender.

2 hours before the test:

- Announce the location of the kitchen counter.
- Announce the location where the operator and the robot will perform the task.

Referee Instructions

The referee needs to:

- Clean any spills as necessary.
- Shuffle the fruits and put all utensils within a reachable distance from the robot.
- Perform a demonstration of the smoothie preparation process for the robot.

Score sheet

The maximum time for this test is 10 minutes.

Action	Score
<i>Main Goal</i>	
Placing all three fruits in the blender	3×200
Pouring a teaspoon of sugar in the blender	300
Pouring milk in the blender	300
<i>Bonus Rewards</i>	
Pouring sugar in the blender without spilling	400
Pouring milk in the blender without spilling	400
<i>Regular Penalties</i>	
Placing an incorrect fruit into the blender	3×-200
<i>Deus Ex Machina Penalties</i>	
Starting the test in front of the kitchen counter	-150
Handing an object over to the robot	-200
Telling the robot which ingredient comes next	-250
Using a custom operator	-250
<i>Special Penalties & Bonuses</i>	
Not attending (see sec. ??)	-500
Using alternative start signal (see sec. ??)	-100
Total Score (excluding special penalties & standard bonuses)	2000

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 a final themed demonstration.

Even though each league has its own first, second and third place, the *Finals* are meant to show the best of all leagues to the jury members as well as the audience and, thus, warrants a single schedule slot.

7.1 Structure and Theme

The *Finals* are a demonstration of achieving an objective that is pre-selected by the TC/EC. These objectives are chosen as a type of yearly theme of the competition, and to provide a baseline for the juries (not to mention the audience) to state which team is the winner.

The objectives for each league for this year are:

- *OPL/DSPL*: The robot helps a person that has had a small accident in their home.
- *SSPL*: The robot monitors a person while they are going about their day and reacts appropriately if it notices any unusual events.

The teams are expected to provide a demonstration that is telling a story which includes achieving the objective. The teams can choose freely how to achieve it, which includes choosing the participants, what items to use, the methods employed, etc. The juries, as explained later, will reward elegance and difficulty.

As it can be seen, the objectives are open enough that a story can be told around them which can include additional objectives that the team wants their robot to also solve. Thus, the teams are welcome to include in their demonstration any additional tasks to be solved, which can serve as a type of forum where they can present their own research. The innovation and success of these tasks will also be used as part of the score (as it is described later). In this regard, it is expected that teams present the scientific and technical contributions they submitted in both *team description paper* and the *RoboCup@Home Wiki*.

In addition, 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.

Story-telling is an important factor, so it is recommended to spend the least amount of time using the microphone to explain the demonstration and let the demonstration speak for itself.

7.2 Evaluating Juries for Final Demonstrations

The *Finals* are evaluated by two juries, here described.

1. **League-internal jury:** The league-internal jury is formed by the Executive Committee. The evaluation of the league-internal jury is based on the following criteria:
 - 1.1. Efficacy/elegance of the solution
 - 1.2. Innovation/contribution to the league of the additional tasks solved

- 1.3. Difficulty of the overall demonstration
2. **League-external jury:** The league-external jury consists of people not being involved in the RoboCup@Home league, but having a related background (not necessarily robotics). They are appointed by the Executive Committee. 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

7.3 Scoring

The final score and ranking are determined by the jury evaluations and by the previous performance (in Stages I and 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 %.

These demonstrations are carried out in a serialized fashion, one League performing after another in one *Arena*.

7.3.1 Task

The procedure for the demonstration and the timing of slots is as follows:

1. **Setup and demonstration:** The team has a maximum of *ten minutes* for setup, presentation and demonstration.
2. **Interview and cleanup:** After the demonstration, there is another *five minutes* where the team answers questions by the jury members.
During the interview time, the team has to undo its changes to the environment.

7.3.2 Changes to the environment

1. **Making changes:** As in the other open demonstrations, teams are allowed to make modifications to the arena as they like, but under the condition that they are reversible.
2. **Undoing changes:** In the interview and cleanup team, changes need to be made undone by the team. The team has to leave the arena in the *very same* condition they entered it.

7.4 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 made it to the *Finals*.

Additional certificates would be granted if:

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