RoboCup@Home

Rules & Regulations

Version: 2015 Rev-58
Last Build Date: January 24, 2015   Time: 1381
Last Revision Date: 2015-01-24

About this rulebook

This is the official rulebook of the RoboCup@Home competition 2015. It has been written by the 2014/2015 RoboCup@Home Technical Committee (in alphabetical order): Loy van Beek, Kai Chen, Dirk Holz, Mauricio Matamoros, Caleb Rascon, Maja Rudinac, Javier Ruiz des Solar, Komei Sugiura, and Sven Wachsmuth.

How to cite this rulebook

If you refer to RoboCup@Home and this rulebook in particular, please cite:

Loy van Beek, Kai Chen, Dirk Holz, Mauricio Matamoros, Caleb Rascon, Maja Rudinac, Javier Ruiz des Solar, Komei Sugiura, and Sven Wachsmuth. "Robocup@Home 2015: Rule and regulations," http://www.robocupathome.org/rules/2015_rulebook.pdf, 2015.

```
@misc{ rulebook_2015,
  author =        {Loy van Beek AND Kai Chen AND Dirk Holz AND
   Mauricio Matamoros AND Caleb Rascon AND
   Maja Rudinac AND Javier Ruiz des Solar AND
   Komei Sugiura AND Sven Wachsmuth},
  title =         {RoboCup@Home 2015: Rule and Regulations},
  year =          2015,
  howpublished = {\url{http://www.robocupathome.org/rules/2015_rulebook.pdf}},
}
```

Acknowledgments

We would like to thank all the people who contributed to the RoboCup@Home league with their feedback and comments. We also like to thank the members of the technical committee who put up the rules and the organizing committee who organizes the competition.

People that have been working on this rulebook as member of one of the league's committees (in alphabetical order):

Loy van Beek	Maja Rudinac
Jean-Daniel Dessimoz	Javier Ruiz-del-Solar
Peter Ford Dominey	Paul E. Rybski
Mohan Rajesh Elara	Jesus Savage
David Gossow	Stefan Schiffer
Dirk Holz	Jörg Stückler
Luca Iocchi	Komei Sugiura
Gerhard Kraetzschmar	Tijn van der Zant
Fariborz Mahmoudi	Sven Wachsmuth
Mauricio Matamoros	Thomas Wisspeintner
Daniele Nardi	Jiongkun Xie
Sven Olufs	Amin Yazdani
Caleb Rascon	

Contents

Chapter 1

Introduction & Regulations

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 robots abilities and performance in a realistic non-standardized home environment setting. Focus lies on the following domains but is not limited to: Human-Robot-Interaction and Cooperation, Navigation and Mapping in dynamic environments, Computer Vision and Object Recognition under natural light conditions, Object Manipulation, Adaptive Behaviors, Behavior Integration, Ambient Intelligence, Standardization and System Integration. It is collocated with the RoboCup symposium.

1.3 Organization

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. Members representing the @Home league:

- Dirk Holz (University of Bonn, Germany)
- Javier Ruiz des Solar (Department of Electric Engineering, Universidad de Chile, Chile)
- Komei Sugiura (National Institute of Information and Communications Technology (NICT), Japan)
- Maja Rudinac (Delft University of Technology, Netherlands)
- Sven Wachsmuth (Bielefeld University, Germany)

1.3.2 Technical Committee — tc@robocupathome.org

The *Technical Committee* (TC) is responsible for the rules of each league. Members of the RoboCup@Home Technical Committee for 2015:

- Kai Chen (University of Science and Technology of China, China)
- Caleb Rascon (Universidad Nacional Autnoma de Mxico, Mexico)
- Loy Van Beek (Eindhoven University of Technology, The Netherlands)
- Mauricio Matamoros (Delft University of Technology, The Netherlands)

The Technical Committee also includes the members of the Executive Committee.

1.3.3 Organizing Committee — oc@robocupathome.org

The *Organizing Committee* (OC) is responsible for the organization of the competition. Members of the RoboCup@Home Organizing Committee for 2015:

- Chair: Maja Rudinac (Delft University of Technology, The Netherlands)
- Local chair: Yinfeng Chen (University of Science and Technology of China, China)
- Farshid Abdollahi (Qazvin Islamic Azad University, Iran)
- Sammy Pfeifer (Pal Robotics, Spain)
- Sebastian Mayer zu Borgsen (Bielefeld University, Germany)
- Viktor Seib (Universitaet Koblenz-Landau, Germany)

1.4 Infrastructure

1.4.1 RoboCup@Home Mailinglist

The official *RoboCup@Home mailing list* can be reached at

robocup-athome@lists.robocup.org

You can register to the email list at:

http://lists.robocup.org/listinfo.cgi/robocup-athome-robocup.org

1.4.2 RoboCup@Home Web Page

The official *RoboCup@Home website* that also hosts this rulebook can be found at

http://www.robocupathome.org/

1.5 Competition

The competition consists of 2 *Stages* and the *Finals*. 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 *Finals* where only the five highest ranked teams compete to become the winner.

1.6 Awards

The RoboCup@Home league features the following *awards*.

1.6.1 Winner of the competition

There will be a 1st, 2nd, and 3rd place award.

1.6.2 Innovation award

To honour outstanding technical and scientific achievements as well as applicable solutions in
the @Home league, a special *innovation award* may be given to one of the participating teams.
Special attention is being paid to making usable robot components and technology available to
the @Home community.

The executive committee (EC) members from the RoboCup@Home league nominate a set
of candidates for the award. The technical committee (TC) elects the winner. A TC member
whose team is among the nominees is not allowed to vote.

There is no innovation award in case no outstanding innovation and no nominees, respectively.

1.6.3 Winner of the RoboZoo

The winner of the RoboZoo in the category of performance is given a special *award for wining
the RoboZoo*. The decision of which team wins have the robot which performs best is made by
an open audience during the RoboZoo test, however, as with the innovation award, the award for
winning the RoboZoo is not given in case the team with the highest score didn't show *sufficient
performance* according by the the Technical Committee (TC) criteria.

1.6.4 Best looking robot

The winner of the RoboZoo in the category of appearance challenge is given a special *award for
best looking robot*. The decision of which team wins have the best looking robot is made by an
open audience during the RoboZoo test.

Chapter 2

Concepts behind the competition

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

2.1 Lean set of rules

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

If, during a competition, there are any discrepancies or multiple interpretations, a decision will be made by the Technical Committee 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

All robots participating in the RoboCup@Home competition have to be *autonomous* and *mobile*.

An aim of RoboCup@Home is to foster mobile autonomous service robotics and natural human-robot interaction. As a consequence humans are not allowed to directly (remote) control the robot. This also includes verbally remote controlling the robot.

Furthermore, the specific tasks must not be solved using *open loop control*.

2.3 Aiming for applications

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

2.4 Social relevance

The competition and the included tests should produce socially relevant results. 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 are: Personal robot assistant, guide robot for the blind, robot care for elderly people, etc. Such socially relevant results are rewarded in RoboCup@Home.

2.5 Scientific value

RoboCup@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 demand a very special configuration or setup. Therefore high scientific value of an approach is rewarded.

2.6 Time constraints

Setup time as well as time for the accomplishment of the tests is very limited, to allow for many participating teams and tests, and to foster simple setup procedures.

2.7 No standardized scenario

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

The scenario is something that people encounter in daily life. It can be a home environment, such as a living room and a kitchen, but also an office space, supermarket, 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, i.e., in an previously unknown environment like, for example, a public space nearby.

2.8 Attractiveness

The competition should be attractive for the audience and the public. Therefore high attractiveness and originality of an approach should be rewarded.

2.9 Community

Though having to compete against each other during the competition, the members of the RoboCup@Home league are expected to cooperate and exchange knowledge to advance technology together. The *RoboCup@Home mailing list* can be used to get in contact with other teams and to discuss league specific issues such as rule changes, proposals for new tests, etc. Every team is expected to share relevant technical, scientific (and team related) information there and in its team description paper (see Section 3.1.4) through the team's website.

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

This is a list of the current desired technical abilities which the tests in RoboCup@Home will focus 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
  RoboCup@Home is aiming for applications of robots in daily life.
- Ambient intelligence, e.g., communicating with surrounding devices, getting information from the internet etc.

Chapter 3

General Rules & 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"*, meaning that additional or contrary rules in particular test specifications have a higher priority than those mentioned herein in the general rules and regulations.

3.1 Team Registration and Qualification

3.1.1 Registration and Qualification Process

Each year there are four phases in the process toward participation:

1. *Intention of Participation* (optional)
2. *Preregistration*
3. *Qualification* announcements
4. Final *Registration* for qualified teams

Positions 1 and 2 will be announced by a call on the *RoboCup@Home mailing list*. Preregistration requires a *team description paper*, a *video* and a *website*.

3.1.2 Qualification Video

As a proof of running hardware, each team has to provide a *qualification video*. As a minimum requirement for qualification, we consider showing the robot(s) successfully solving at least one test of the current or last year's rulebook.

3.1.3 Team Website

The *Team Website* has to contain photos and videos of the robot(s), a description of the approaches, and information on scientific achievements, relevant *publications*, team members, and previous participation in RoboCup.

The information on the team website has to be in English and should be designed for a broader audience.

3.1.4 Team Description Paper

The *team description paper* (TDP) should at least contain the following sections:

- Name of the team

- contact information
- website
- team members
- description of the hardware, including photo(s) of the robot(s)
- description of the software

Preferably, it should also contain the following:

- 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 the real world

The TDP has to be in English, up to eight pages in length and formatted according to the guidelines of the RoboCup International Symposium. It goes into detail about the technical and scientific approach.

3.1.5 Qualification

During the *qualification process* a selection will be made by the organizing committee. Taken into account and evaluated in this decision process are:

- The information on the team website and the qualification video,
- the information in the *team description paper*, and
- the information in the *RoboCup@Home Wiki* (added by the team).

(Additional) evaluation criteria are:

- the performance in previous competitions,
- the relevant scientific contributions and publications, and
- the contributions to the RoboCup@Home league.

For getting considered in the evaluation, be sure to insert your team's name when adding information to the *RoboCup@Home Wiki*.

3.2 Scenario

The tests take place in the *RoboCup@Home arena*. In addition, particular tests are situated outside the arena, e.g., in a previously unknown public place. The following rules are related to the *RoboCup@Home arena* and its contents.

3.2.1 RoboCup@Home arena

The *RoboCup@Home arena* is a realistic home setting consisting of inter-connected rooms like, for instance, a living room, a kitchen, a bath room, and a bed room.

(a) Typical arena
(b) Typical objects

Figure 3.1: Scenario examples: (a) a typical arena, and (b) typical objects.

3.2.2 Walls, doors and floor

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

1. **Walls:** Walls have a minimum height of 60 cm. A maximum height is not specified, but should be chosen so that the audience is able to watch the competition.
   Walls will be fixed and are likely to be not modified during the competition (see Section 3.2.4).
2. **Doors:** There will be at least two entry/exit *doors* connecting the outside of the scenario. These doors are used as starting points for the robots (see Section 3.6.8). There will be also another door inside the scenario with a handle (not a knob) between any two rooms.
3. **Floor:** The floor of the arena as well as the doorways of the arena are even. That is, there will be no significant steps or even stairways. However, minor unevenness such as carpets, transitions in floor covering between different areas, and minor gaps (especially at doorways) must be expected.
4. **Appearance:** Floor and walls are mainly uni-colored but can contain texture, e.g., a carpet on the floor, or a poster or picture on the wall.
   Although being unlikely at the moment, transparent elements are also possible.

3.2.3 Furniture

The arena will be equipped with typical objects (furniture) that are not specified in quantity and kind. The minimal configuration consists of

- a small dinner table with two chairs,
- a couch,
- an open cupboard or small table with a television and remote control,
- a cupboard or shelf (with some books inside), and
- a refrigerator in the kitchen (with some cans and plastic bottles inside).

A typical arena setup is shown in Figure 3.1a.

3.2.4 Changes to the arena

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

1. **Major changes:** Changes will primarily influence the position of objects such as furniture inside the arena while walls are likely to stay fixed. Multiple changes may take place up to completely restructuring the internals of the apartment. The position of named locations (see Section 3.2.8) are not changed when used in a test, e.g., as navigation goal.
   In addition, passages may be blocked and cleared, respectively. One hour before a test slot begins no *major changes* will be made.
2. **Minor changes:** In contrast to major changes, *minor changes* like, for instance, slightly moved chairs cannot be avoided and may happen at any time (even during a test).

3.2.5 Predefined objects

Some tests in the RoboCup@Home league involve the manipulation of objects. These objects resemble items usually found in household environments like, for instances, soda cans, coffee mugs or books. An example of objects used in a previous competition can be seen in Figure 3.1b.

1. **Definition:** The TC will compile a list of 25 objects. There are no restrictions on object size, appearance or weight. However, it can be expected that the selected objects are easily manipulable by a human using a single hand.
2. **Object classes:** Each object will be assigned to an *object class*. The objects 'lemonade' and 'ice tea' may be of class 'beverage' for example.
3. **Object (class) locations:** Each object (class) will be assigned to an *object location*. Objects of class 'drink' may be usually found on the 'kitchen table' for example.
4. **Announcement:** The TC makes the set of objects (and their names, classes, and usual locations) available during the setup days.
5. **Known vs. unknown**: These objects are used as the *known objects* in the test specifications; *unknown objects* are not taken from the set of *predefined objects*.
6. **Placement:** In manipulation tasks, the objects will be positioned at *manipulation locations* and less than 15 cm away from the border of the surface they are located at. There will be at least 5cm space around each object.

3.2.6 Predefined locations

Some tests in the RoboCup@Home league involve *predefined locations*. These may include places like a 'bookshelf' or a 'dining table', as well as certain objects such as a 'television', or the 'front door'.

1. **Definition:** The TC will compile a list of predefined locations. There are no restrictions on which parts of the arena will be selected as a predefined location.
2. **Location classes:** Each location will be assigned to a *location class*. The objects 'couch' and 'arm chair' may be of class 'seat' for example.
3. **Announcement:** The TC makes the set of locations (and their names and classes) available during the setup days.

4. **Position:** The positions of locations are *not* necessarily fixed (see Section 3.2.4).
5. **Manipulation locations:** The TC will mark 20 locations out of the set of predefined locations as being *manipulation locations*. Whenever a test involves manipulation, the object to manipulate will be placed at one of the manipulation locations.

3.2.7 Predefined rooms

Some tests in the RoboCup@Home league involve *predefined rooms*.

1. **Definition:** The TC will compile a list of room names.
2. **Announcement:** The TC makes the set of rooms available during the setup days.

3.2.8 Predefined (person) names

Some tests in the RoboCup@Home league involve *predefined names* of people.

1. **Definition:** The TC will compile a list of 20 predefined names. The names are 50 % male and 50 % female, and taken from the (current) most common first names in the United States.
   In order to ease speech recognition, it is tried to select names to be phonetically different from each other.
2. **Announcement:** The TC makes the set of names available during the setup days.
3. **Assignment:** When a test involves interacting with persons (using a person's name), all involved persons are assigned names by the referees before the test.

Typical names are, for example, James, John, Robert, Michael and William as male names; Mary, Patricia, Linda, Barbara and Elizabeth as female names.

3.2.9 Wireless network

For wireless communication, an *arena network* is provided. The actual infrastructure depends on the local organization.

- To avoid interference with other leagues, this WIFI has to be used for communication only. It is not allowed to use the above or any other WIFI network for personal use at the venue.
- During the competitions, only the active team is allowed to use the *arena network*.
- The organizers cannot guarantee reliability and performance of wireless communication. Therefore, teams are required to be ready to setup, start their robots and run the tests even if, for any reason, network is not working properly.

3.2.10 Smart Home Devices

todo: Finish writing this section. There is a list of official devices that can be used in some tests for additional score. The protocol to communicate with these devices will be provided well beforehand the competition.

3.3 Robots

3.3.1 Autonomy & Mobility

Robots that participate in the RoboCup@Home league need to be *autonomous* and *mobile*. Any deviations reported to the TC, may result in a penalty for the team (see Section 3.7.2).

3.3.2 Number of robots

1. **Registration:** The maximum *number of robots* per team that can be registered for the competitions is *two* (2).
2. **Regular Tests:** Only one robot is allowed per test. For different tests different robots can be used.
3. **Open Demonstrations:** In the Open Challenge and the Finals both robots can be used simultaneously.
4. **RoboZoo:** In the RoboZoo both robots can be used simultaneously as long as they fit into the cage.

3.3.3 Size and weight of robots

1. **Dimensions:** The dimensions of a robot should not exceed the limits of an average door, which is 200 cm by 70 cm in most countries.
   The TC may allow the qualification and registration of larger robots, but due to the international character of the competition it cannot be guaranteed that the robots can actually enter the arena. In case of doubt, contact the local organization.
2. **Weight:** There is no specific weight restriction. However, the weight of the robot and the pressure it exerts on the floor should not exceed local regulations for the construction of buildings which are used for living and/or offices in the country where the 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 with an easy and fast procedure.

3.3.4 Emergency stop button

1. **Accessibility and visibility:** Every robot has to provide an easily accessible and visible *emergency stop* button.
2. **Color:** It must be coloured red, and preferably be the only red button on the robot. If it is not the only red button, the TC may ask the team to tape over or remove the other red button.
3. **Robot behavior:** When pressing this button, the robot and all parts of it have to stop moving immediately.
4. **Inspection:** The emergency stop button is tested during the *Robot Inspection* test (see Section **??**).

3.3.5 Start button

1. **Requirements:** As stated in Section 3.6.7, 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. The team needs to announce this to the TC before every test that involves a start signal, including *Robot Inspection*.
2. **Definition:** The start button can be any "one-button procedure" that can be easily executed by a referee. This includes, for example, the release of the *emergency button* (Section 3.3.4), a hardware button different from the *emergency button* (e.g., a green button), or a software button in a Graphical User Interface.
3. **Inspection:** It is during the the *Robot Inspection* test (see Section **??**) that the procedure for the start button, if needed, is announced to the TC and inspected. The start button for a robot should be the same for all the tests.
4. **Penalty for using start button:** If a team needs to use the start button in a test where opening the door is the start signal, it may receive a penalty (see Section 3.6.7).

3.3.6 Appearance and safety

Robots should have a nice product-like appearance, be safe to operate and should not annoy its human users. The following rules apply to all robots and are part of the *Robot Inspection* test (see Section **??**).

1. **Cover:** The robot's internal hardware (electronics and cables) should be covered in an appealing way. The use of (visible) duct tape is strictly prohibited.
2. **Loose cables:** There may not be any loose cables hanging out of the robot.
3. **Safety:** The robot may not have sharp edges or other things that could severe people.
4. **Annoyance:** The robot should not permanently make loud noises or use blinding lights.

3.3.7 Audio output plug

1. **Mandatory plug:** Either the robot or some external device connected to it *must* have a *speaker output plug*. It is used to connect the robot to the sound system so that the audience and the referees can hear and follow the robot's speech output.
2. **Inspection:** The output plug needs to be presented to the TC during the *Robot Inspection* test (see Section **??**).
3. **Audio during tests:** Audio (and speech) output of the robot during a test have to be understood at least by the referees and the operators.
   - It is the responsibility of the teams to plug in the transmitter before a test, to check the sound system, and to hand over the transmitter to next team.
   - Do not rely on the sound system! For fail-safe operation and interacting with operators make sure that the sound system is not needed, e.g., by having additional speakers directly on the robot.

3.4 External devices

1. **Definition:** Everything which is not part of the robot is considered an *external device*.

2. **Inspection:** In general, external devices are not allowed unless presented and explained to the Technical Committee during the *Robot Inspection* test (see Section **??**).

3. **Supervision:** In regular tests, external devices may only be used under supervision by referees and after approval by the TC. The devices have to be brought to the arena for every test, and removed quickly after the test.

4. **Open demonstrations:** For the Open Challenge, RoboZoo, and the finals, external devices are allowed, still their use needs to be announced beforehand.

5. **Wireless devices:** All *wireless devices* including bluetooth devices, walkie-talkies, and anything else that uses an RF signal to operate need to be announced to the *Organizing Committee (OC)*. The use of any wireless device not approved by the TC is strictly prohibited.

6. **Artificial landmarks:** *Artificial landmarks* and *markers* are not allowed.

7. **Computing devices:** External computers for decentralized computations are allowed, but have to be inside the arena, i.e., not on its periphery.

8. **Wireless LAN:** The use of networks other than the *arena network* (see Section 3.2.9) is strictly prohibited.

9. **External microphones:** *External microphones*, hand microphones, and headsets are not allowed. Using an *on-board microphone* is mandatory for communication with the robot.

3.5 Organization of the competition

3.5.1 Stage system

The competition features a *stage system*. It is organized in two stages each consisting of a number of specific tests. It ends with the finals.

1. **Stage I:** The first days of the competition will be called *Stage I*. All qualified teams can participate in Stage I. Stage I comprehends a set of *Ability Tests* and an *Integration Test*. Those *Proficency Tests* are performed at least 3 times each one. The *RoboZoo* is the open demonstration in Stage I.

2. **Stage II:** The best *50% of teams with full integrated capabilities*[1] (after Stage I) advance to *Stage II*. Here, more complex abilities or combinations of abilities are tested. In order to advance to Stage II a team must successfully solve 3 out of 5 of the *Proficency Tests* in Stage I The *Open Challenge* is the open demonstration in Stage II.

3. **Final demonstration:** The best *five teams* (after Stage I and Stage II) advance to the final round. The final round features only a single open demonstration.

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.

3.5.2 Number of tests

1. In Stage I, the *maximum number of tests* that a team can participate in is *five (5)*.
2. In Stage II, the *maximum number of tests* that a team can participate in is *four (4)*.

---

[1]If the total number of teams is less than 20, up to 10 teams may advance to Stage II

3. None of the tests is mandatory, except for the *Robot Inspection* test (see Section **??**), the *Robo-Zoo* test (see Section **??**), and the *Basic Functionalities* test (see Section **??**).
4. Teams have to indicate to the organizing committee in which tests they are going to participate. Otherwise, they are automatically added to all test schedules and may receive a penalty when not attending (see Section 3.7.1).

3.5.3 Schedule

1. **Tests:** The organizing committee (OC) provides schedules for all tests and teams.
2. **Slots:** The tests will be held in *test slots* of approximately two hours.
3. **Preparation:** The organizing committee (OC) provides schedules for all teams to organize the access to the arena between test slots. In these *preparation slots* the teams may conduct calibration procedures, remap the arena if necessary, or conduct test runs. Preparation slots are inserted whenever possible, but may not be available before all test slots.
4. **Arena access:** One hour before a test slot, only the teams participating in that slot are allowed in the arena. This rule only applies when not having organized *preparation slots*.

3.5.4 Score system

1. **Stage I:** The maximum total score in Stage I is *100 points*.

   1.1. ***Proficency Tests*:** The maximum total score is calculated as the average of the best two runs for that test
   1.2. **RoboZoo:** The maximum score for RoboZoo is *5 points*.

2. **Stage II:** Test in Stage II are rewarded on a task-solved scoring basis.

   2.1. Each test but the Open Challenge has a main task. The base score for solving the main task is *25 points*.
   2.2. The maximum score for Open Challenge is *20 points*.
   2.3. Optionals and subtasks add bonus points to the main task score.

3. **Finals:** Final score is normalized and special evaluation is used
4. **Special tests:** Tests may specify a maximum total score deviating from the general maximum total scores.
5. **Minimum score:** The minimum total score per test in Stage I and Stage II is *0 points*. That is, if the total score for a test is below zero, the team does not receive any points.
6. **Penalties:** An exception to the *minimum score* rule are penalties. Both penalties for not attending (see Section 3.7.1) and extraordinary penalties (see Section 3.7.2) can cause a total negative score.
7. **Partial scores:** All tests—except for the open demonstrations—are rewarded on a partial scoring basis.

   7.1. Tests are split into designated parts.
   7.2. Each part is assigned a certain number of points.
   7.3. A team that successfully passes a designated part of the test receives points for that part.
   7.4. In case of partial success, referees (and TC members) may decide to only award a percentage instead of the full partial score.

7.5. The total score for a test is the sum of partial scores.

7.6. Partial scores can be negative (e.g. to penalize failures etc.).

3.5.5 Open Demonstrations

1. **Stage I:** The *RoboZoo* is the open demonstrations in Stage I.

   1.1. Teams can demonstrate freely chosen abilities.

   1.2. The performance is evaluated by an open audience.

   1.3. The RoboZoo is described in Section **??**.

2. **Stage II:** The *Open Challenge* is the open demonstration in Stage II.

   2.1. To participate in the Open Challenge, a team needs to participate in at least one regular Stage II test.

   2.2. Teams can demonstrate freely chosen abilities.

   2.3. The performance is evaluated by a jury consisting of the Technical Committee.

   2.4. The Open Challenge is described in Section **??**.

3. **Finals:** The competition ends with a final demonstration.

   3.1. The concept of the final demonstration is the same as that of the Open Challenge, but the performance evaluation is different.

   3.2. The are two juries—an *external* consisting of three or more people not from the RoboCup @Home league, and an *internal* formed by the Executive Committee. Both juries have different sets of evaluation criteria.

   3.3. Members of the external jury are selected by the Executive Committee on site.

   3.4. The demonstration in the finals does not have to be different from the one shown in the Open Challenge. It does not have to be the same either.

3.6 Procedure during Tests

3.6.1 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 has to be stopped *immediately*.

3. **Penalties:** If the team does not comply, the team and its members can be excluded from the ongoing competition immediately by a decision of the RoboCup@Home Technical Committee. Furthermore, the team and its members can be banned from future competitions for a period not less than a year by a decision of the RoboCup Federation Trustee Board.

3.6.2 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). The only exceptions are tests that require for more team

members in the arena.

2. **Setup:** During the setup of a test, the number of team members inside the arena is not limited.
3. **Open Demonstrations:** During the Open Challenge, and the final demonstration, 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 event (see Section 3.6.12).

3.6.3 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.

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

3.6.4 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/or required by the test specification.
2. **Natural interaction:** The only allowed means to interact with the robot(s) are gestures and speech.
3. **Natural commands:** Only general instructions are allowed. Anything that resembles direct control is prohibited.
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 can lead to penalties in the form of negative scores, and disqualification for a test or even for the entire competition.

3.6.5 Collisions

1. *Touching*: Robots are allowed to gently *touch* objects, items and humans. They are not allowed to crash into something. The "safety first" rule (Section 3.6.1) supercedes all other rules.

   - It *is* allowed however to *functionally* touch an item with e.g. the base.

   The OC/TC/EC and the RoboCup Trustees all have the right to immediately stop a robot, and to disqualify a team for the duration of the competition, or longer, in case of

dangerous behavior. Furthermore, referees can recommend to disqualify a team in which case EC/TC decides.

2. ***Major collisions*****:** If a robot crushes into something during a test, the robot is immediately stopped. Additional penalties may apply.

3. **Robot-Robot avoidance:** If two robots encounter each other, they both have to actively try to avoid the other robot.

    3.1. A robot which is not going for a different route within a reasonable amount of time (e.g., 30 s) is removed.

    3.2. A non-moving robot blocking the path of another robot for longer than a reasonable amount of time (e.g., 30 s) is removed. In this context, "moving" refers to any kind of motion or action required in the test. For example, a robot standing still but manipulating an object does not need to stop manipulating and move away, even when blocking the way of another robot for the duration of the manipulation.

3.6.6 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 has to immediately stop the robot, and remove it from the arena without disturbing the ongoing test.

3.6.7 Start signal

1. **Opening the door:** Unless stated otherwise, the cue for the robot to enter the arena and start the test is the opening of the door by a referee.

2. **Start button:** If the robot is not able to automatically start after opening the door, the team may start the robot using a start button.

    2.1. Using a start button needs to be announced to the referees. It is the responsibility of the team to do so before the test starts.

    2.2. There may be penalties for using a start button in some tests

3.6.8 Entering and leaving the arena

1. **Start position:** Unless stated otherwise, the robot starts outside of the arena.

2. **Entering:** The robot has to 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.

3.6.9 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.

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.

3.6.10 Referees

1. **Setup:** Unless stated otherwise, each test is monitored by two referees and one member of the Technical Committee.
2. **Selection:** The two referees

   - are chosen by EC/TC/OC,
   - are announced together with the schedule for the test slot,
   - and have to referee all teams in that slot.
   - Referees may not be from one of the teams in the slot.

3. **Not showing up:** Not showing up for refereeing (on time) will result in a penalty (see Section 3.7.2).
4. **TC monitoring:** The referee from the TC acts as a main referee.
5. **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.

3.6.11 Operator

1. **Default operator:** The robots are operated by the monitoring TC member, a referee, or by a person selected by the TC.
2. **Fallback/custom operator:** If the robot fails to understand the command given by the default operator, the team may continue with a custom operator.
   - The custom operator may be any person chosen by the team (and willing to do so); including the referees or the monitoring TC member.
   - A penalty may be involved when using a custom operator.

3.6.12 Moderator

1. **Providing a moderator:** For each regular test (i.e., not for the open demonstrations), all participating teams need to provide a team member as moderator for the duration of their performance.

2. **Responsibilities:** The moderators have to:
   - explain the rules of the test,
   - comment on the performance of their team,
   - not interfere with the performance,
   - speak in English,
   - and obey the instructions by the monitoring TC member.
3. **Competitive tests:** In competitive tests (tests in which two teams directly compete against each other), the moderation has to be done by the two teams together.

3.6.13 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. **Setup time:** Unless stated otherwise, all time specifications, e.g., setup time and time for instructing operators, are within the total test time.
4. **Scores:** When the time is up, the team has to immediately remove their robot(s) from the arena; no more points can be scored. In special cases, the monitoring TC member may ask the team to continue the test for demonstration purposes (points cannot be scored).

3.6.14 Restart

1. **Number of restarts:** A team may request one (1) restart during a test, unless stated in otherwise. There are tests in which a restart is not allowed.
2. **Procedure:** In case a restart is allowed, the team may request the restart only before 50% of the time alloted to the test. The complete test is then restarted from the beginning (e.g., with entering the arena). The referees may rearrange the locations of objects/persons if necessary.
3. **Time:** The time is neither restarted nor stopped. The team has 1 minute to restart the test (the same time to start the test); if the team is not able to do so in the allotted time, the test is called as finished by the TC.
4. **Score:** The score of the second run (after the restart) counts. If it is lower than the score of the first run (before the restart), the average score of first and second run is taken.
5. **Forced restart:** The referees and the monitoring TC member may force the team to do a restart:
   - if the robot is doing nothing or nothing reasonable for *one minute*, or
   - when the robot fails to understand a command for *five times*.

3.6.15 Bypassing Automatic Speech Recognition: Continue

Giving commands to the robot is an important part of many tests. RoboCup@Home fosters natural human-robot interaction through gestures and speech, such that speech is the primary modality to give complex commands to the robot. Due to the sequential nature of many tests and the difficulty of ASR in the international competition environment of RoboCup, the team is allowed to take up to 2 alternative means to provide a command to the robot, for which the robot continuously fails to recognize the spoken command. These alternative means should be

declared in the registration form and checked by the TC during the *Robot Inspection* test (see Section **??**).

In future competitions, this rule will be gradually removed. Hence, solutions are encouraged that either resolve the ASR failure through spoken dialogues or solving the task in an alternative way (no penalty), or that use appealing modalities to provide the command (less penalty than direct typing on the robot).

1. **Number of Continue's:** The team leader may request up to two (2) Continue's during a test.
2. **Procedure:** In case a Continue is allowed, the team may request the Continue only at moments in which the robot is failing at carrying out ASR (no pre-emptive Continue's are allowed). A TC member gives the command through the alternative input modality. S/he provides exactly what the user has spoken. The Continue rule will not be allowed, if the robot does not have a keyboard attached or the alternative input modality was not accepted by the TC, or if it is not able to process ASR commands and alternative commands simultaneously.
3. **Time:** The time is neither restarted nor stopped while the Continue rule is applied.
4. **Score:** If one Continue was asked for, the points provided for the ASR part of the test (if any) will be zero and the total points for the test will be multiplied by a factor of 0.5 if the modality of the alternative solution is by typing on a keyboard. To promote other means of interaction, if the modality is different than keyboard typing (i.e. touch interface), the factor to be applied will be 0.75. If two Continues were asked for, the factor will be applied twice.

Alternative methods

Below are some suggested alternatives for ASR:

- A QR code encoding a text is shown to the robot on a laptop screen.
- The robot hosts a website on which some text can be entered.
- A laptop connects to the robot over e.g. ssh where some command can be entered.
- ...

3.7 Special penalties and bonuses

3.7.1 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 *500 points*.

3.7.2 Extraordinary penalties

1. **Penalty for inoperative 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 *-100 points* is handed out. The decision is made by the referees and the monitoring TC member.
2. **Extra penalty for collision:** In case of major, (grossly) negligent collisions the TC may disqualify the team for a test (the team receives *0 points*), or for the entire competition.
3. **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 *500 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 challenge (receives *0 points*).

3.7.3 Bonus for outstanding performance

1. For every regular test in Stage I and Stage II, the @Home Technical Committee 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 beforehand.
4. It is the decision of the TC if (and to which degree) the bonus score is granted.

3.8 Best Test Score Certificate

A certificate will be given to the team with the highest score in each test of Stage 1 and 2.

1. **Requirements:** The score obtained must be at least 70% of the maximum score of the test.

3.9 General Instructions for Organizing Committee

Although there are instructions for the OC are specified per test, there are several aspects that the OC requires to carry out for competition in general:

During competition:
- Provide TC and referees with scoring sheets, pens, clipboards, stopwatches and other material relevant of carrying out the scoring.
- Post time schedules in the allotted spaces for the team's knowledge.

1h before each test:
- Organize referees.

Chapter 4

Setup and preparation

todo: Write Setup section

Chapter 5

Tests in Stage I

*Stage I comprehends four **ability tests** and an **integration test** along with an open demonstration for the audience. Each ability test is designed to evaluate the average performance of the robot in one particular skill, providing data for benchmarking. Meanwhile, the integration test has been designed to evaluate how this abilities work together while solving a common task.*

The total score for ability and integration tests is the average of the best two performances.

RoboZoo (open demonstration for the audience) have no changes from previous years' competitions and is intended to show to an open audience what domestic robots can do. This test grants up to 5 points.

5.1 GPSR

This test evaluates Human-Robot Interaction and the integration of the abilities of the robot tested in stage I. In this test the robot has to solve multiple tasks upon request. That is, the test is not incorporated into a (predefined) story and there is neither a predefined order of tasks nor a predefined set of actions. The actions that are to be carried out by the robot are randomly generated by the referees and are composed by 3 subtasks which include navigation, human-robot interaction and robot-object interaction.

The command is composed by three actions, which the robot has to show it has recognized. The robot may repeat the understood command and ask for confirmation. If it can't recognize the command correctly, it can also ask the speaker to repeat the complete command.

5.1.1 Focus

This test particularly focuses on the following aspects:

- No predefined order of actions to carry out (to get away from state machine-like behavior programming).
- Increased complexity in speech recognition.

5.1.2 Task

1. **Entering and command retrieval:** The robot enters the arena and drives to a designated position where it has to wait for further commands.
2. **Command generation:** A command is generated randomly. The command must contain at least one of each of the following components

    - Navigation (robot will need to move somewhere else).
    - Human-robot interaction (such as: people detection, recognition, and tracking; online training, answering predefined questions).
    - Robot-Object interaction (such as: object detection, object recognition, and object manipulation).

    The command is composed by three actions, which the robot has to show it has recognized. The robot may repeat the understood command and ask for confirmation. If it can't recognize the command correctly, it can also ask the speaker to repeat the complete command. If the robot fails to understand the given commands, it may ask to the operator to repeat them up to three times, if it fails the team may opt to use the Continue rule (Section 3.6.15). In case the robot has understood partially the command, it may ask the operator for additional information (e.g. "did you say apple juice or orange juice?").
3. **Task assignment:** The robot is given the command by the operator and may directly start to work on the task assignment.
4. **Exiting the arena:** After accomplishing the assigned task, the robot has to leave the arena.

Command examples

- Go to the bedroom, find a person and tell the time (missing object-interaction part).

- Go to the kitchen, find a person and follow her (missing object-interaction part).
- Go to the dinner-table, grasp the crackers, and take them to the TV.
- Go to the shelf, count the drinks and report to me.
- Take this object and bring it to Susan at the hall.
- Bring a coke to the person in the living room and answer him a question.
- Offer a drink to the person at the door.

5.1.3 Additional rules and remarks

1. **Referees:** Since the score system in this test involves a subjective evaluation of the robot's behavior, the referees are EC/TC members.
2. **Operator:**
   - The person operating the robot is one of the referees (default operator).
   - If the robot appears to consistently not be able to understand the operator, the referees ask the team to continue with a custom operator (Section 3.6.11).
   - With the custom operator, the team can only score 50% of the points for the respective command.

5.1.4 Referee and OC instructions

h before test:

- Specify and announce the entrance and exit door

During the test:

- Generate random sentences by an automatic sentence generator

5.1.5 Score sheet

The maximum time for this test is 8 minutes.

Action	Score
Performing the task	
Understanding the set of actions on the first attempt	4.0
Performing the first command correctly	4.0
Performing the first and second command correctly	6.0
Successfully solving the complete task	10.0
Exiting the arena	1.0
Penalty for own operator	
Reduction of points for command provided by a team member	−2.0
Total score (excluding penalties and bonuses)	25.0

5.2 Manipulation and Object recognition

The robot must reach a bookcase or table in which there are several objects at different heights (top-most or bottom-most shelf) or positions (one very close from other at the table). The robot must then identify and grasp all of those objects and put them all together into a new, easy-to-reach location (middle shelf or another table).

5.2.1 Goal

The robot has to identify, grasp and correctly place several objects at different heights or positions.

5.2.2 Focus

This test focuses on object detection, and manipulation; as well as object recognition.

5.2.3 Setup

This test may also be held outside the arena

1. **Location:** One of the bookcases of the apartment is used for this test. The robot will start at a random distance between 1.0m and 1.5m from the bookcase. [1] The bookcase has at least 5 shelves between 0.30m and 1.80m from the ground. One of the shelves in the middle is empty.
2. **Objects:** The bookcase contains 5 objects from the set of predefined objects.
3. **Object distribution:** The objects are located as follows:

    3.1. An easy-to-grasp (bottle, small cereal box, can, etc...) object on a top shelf.
    3.2. An easy-to-grasp (bottle, small cereal box, can, etc...) object on a bottom shelf.
    3.3. A heavy object (1L milk box, big soda bottle, etc...) on a middle shelf.
    3.4. A hard-to-grasp object (cloth, apple, banana, etc...) on a middle shelf.
    3.5. A hard-to-reach object (near a corner or a wall) on a middle shelf.

  Optional An ocluded or hidden object on a middle shelf (e.g. behind another object or inside a bowl).

    Please note that may be more than one object in each shelf.

5.2.4 Task

1. **Searching for objects:** When told so by an operator, the robot approaches to the shelf and start searching for objects.
2. **Grasping objects:** Any object found by the robot may be grasped by it. Before or right after grasping the object, the robot has to announce which object it has found.
3. **Placing objects:** After grasping the object, the robot has to safely place it (Section 3.2.5) on the empty shelf a the middle of the bookcase. The object must stay there for at least 10sec.

---

[1]The minimum and maximum distance of the objects in the shelf is still being discussed. This value may change.

4. **Handling objects multiple times:** Scores can only be gained a single time for each specific object.

5.2.5 Additional rules and remarks

1. **No setup:** The robot must be ready to start the test with a voice command or start button when requested by the referee. There is no setup time.
2. **Startup:** The robot must be started with a single voice command or via a start button (Section 3.6.7). If the robot is unable to start it must be removed immediately.
3. **Single try:** The robot must be able to start from the first attempt. There is no restart for this test. If the robot is unable to start it must be removed immediately.
4. **Collisions:** Slightly touching the shelves or the bookcase is tolerated. Driving over the objects or any other form of a major collision is not allowed, and the referees directly stop the robot (Section 3.6.1).
5. **Object types:** The objects selected from the *Standard Objects Set* will be chosen to be easily detectable and contrasting with the shelf (ex. red or black objects on a white shelf).
6. **Recognition report:** After the test is completed or the time has run out, the robot may upload a single PDF report file including the list of recognized objects with a picture showing the object, the object name, and the bounding box of the object.

5.2.6 Referee instructions

The referee needs to

- Place the objects in the bookcase
- Make sure there is one empty shelf in the middle of the bookcase

5.2.7 Score sheet

The maximum time for this test is 3 minutes.

Action	Score
Grasping objects	
Grasping any object (and successfully lifting it up to at least 5 cm for more than 10 second)	5×1.0
Placing objects	
Placing any object (safely and the objects stands still for more than 10 second)	5×1.0
Recognizing objects	
Every correctly recognized object in the report file	5×1.0
Hidden object optional (up to 5 points)	
Finding a hidden or ocluded object	5.0
Total score (excluding penalties and bonuses)	**20.0**

---

[1]The minimum and maximum distance of the objects in the shelf is still being discussed. This value may change.

5.3 Navigation Test

The robot must enter the arena, visit each one from a set of waypoints, and leave the arena. The path from a waypoint to another is always blocked by an obstacle that requires the robot to take an action to solve the task.

Actions may include: avoid the obstacle, find a different path, or even interact with the obstacle (move it, open it, ask it to move, wait for it to move, etc.).

5.3.1 Goal

The robot must be able navigate through the apartment and avoid some difficult obstacles along the way.

5.3.2 Focus

The navigation test focuses on navigating in a changing environment, where doors can be closed and even paths to goal may get blocked by movable temporary objects.

Perceiving the obstacles is also critical in safely navigating a home environment.

5.3.3 Setup

1. **Location:** One of the arenas (apartment). The apartment is in its normal state.
2. **Doors:** All doors in the apartment are open, except for the entry door. The arena/apartment must contain 2 doors within the apartment (thus excluding the entry/exit doors). Any destination in the room should be reachable via either door but not via any other way.

5.3.4 Task

The robot must visit a set of waypoints and avoid the obstacles on it's path (All waypoints are related to furniture in the arena, such as a table, a couch or a plant etc.).

1. **Entering the arena:** The robot starts outside the environment and must wait until the door opens.
2. **Waypoint A (door):** The robot must navigate to waypoint A. Waypoint A is reachable via several paths that include doors. One of the doors will be shut. The robot may:

   2.1. To take a different path.
   2.2. Open the closed door.

   The robot must report whether it reached the waypoint.
3. **Waypoint B (dynamic obstacles):** After reaching waypoint A, the robot must navigate to waypoint B which is also reachable via (the same) two doors, one of each may still be closed. On it's path the robot may find a dynamic obstacle (movable people, other robot, pets, etc.) which blocks it's path to waypoint B. The robot may:

   3.1. To take a different path.
   3.2. Ask the obstacle to move out.
   3.3. Wait for the object to move away by itself.

   The robot must report whether it reached the waypoint.

4. **Leave the arena:** Go outside the arena through the same the robot started.

Note   Objects will be placed during the test in the robot's path which it must avoid. The closing / opening doors give the Technical Committee the possibility to change the order in which the obstacles are encountered, so there is no predefined order of obstacles encountered. Waypoint A and B are interchangeable.

5.3.5 Additional rules and remarks

1. **Make it fast:** If a robot is absolutely unable to handle one or more obstacles, please inform the TC before the test so no time is wasted.
2. **Closing doors:** The door that will be shut will be the door on the route the robot has committed to. It will be shut right after the robot starts driving towards the door. The door will be closed well before the robot reaches it so the robot has enough time to notice that the door closed.
3. **Obstacles:** obstacles may be:

Obstacle 1: Box sized item placed around a corner.
Obstacle 2: A static obstacle on or very near one of the waypoint. If the robot cannot reach the waypoint, it must report so by speech and continue the test. For example, a person may be standing in front of a couch and a chair may be placed at the table.
Obstacle 3: A bar table, normal table, rolling chair: some object that is wider at its top than on its bottom, thus requiring more than just a laser scanner mounted near the ground to avoid obstacles. This will be placed in the middle of some room, on or near the robots path.

4. **Moving objects:** If the robot finds on it's way a *static movable obstacle* (chair, cubes, toys, etc.) which is capable to move, it may move the object apart with it's manipulator.

5.3.6 Score sheet

The maximum time for this test is 5 minutes.

Action	Score
Waypoints	
Reaching waypoint A	1.0
Reaching waypoint B	1.0
Obstacles	
Avoiding obstacle 1	2.0
Avoiding obstacle 2	3.0
Avoiding obstacle 3	4.0
Reporting unreachable waypoint due to an obstacle (will end the test)	1.0
Doors	
Starting a new path after reaching a closed door	2×2.0
Opening the door and continue instead of plan a new trajectory	2×4.5
Total score (excluding penalties and bonuses)	**20.0**

5.4 Person recognition test

An Operator is introduced to the robot, which needs to learn how the Operator looks like. Once the robot has gathered enough information about the Operator, the Operator mixes within a crowd and the robot needs to find the Operator. Once the robot has found it's Operator, it must explain how it must state information about the Operator, such as mood and gender.

5.4.1 Goal

The robot has to identify the Operator within a crowd and state information about the Operator and the crowd.

5.4.2 Focus

This test focuses on people detection and recognition; as well as pose recognition and human-robot interaction with unknown people.

5.4.3 Setup

1. **Operator:** A "professional" operator is selected by the TC to test the robot.
2. **Other people** There are no restrictions on other people walking by or standing around throughout the complete task.

5.4.4 Task

This test may also be held outside the arena

1. **Start:** The robot starts at a designated starting position, and waits for the "professional" operator. When the referees start the time, the team is not allowed to instruct the operator.
2. **Memorizing the operator:** The robot has to memorize the operator. During this phase, the robot may instruct the operator to follow a certain setup procedure.
3. **Wait for Start Command:** Once the robot states it has finished memorizing the operator, it must wait for a Start Command via ASR (or using the Continue rule if need be; Section 3.6.15) while the operator walks around the robot and locate behind him within a crowd.
4. **Find the crowd:** After the time elapses, the robot must turn about 180, approach to the crowd and start looking for the operator.
    - **Crowd size:** The crowd may contain between 5 and 10 people, standing or sitting or lying within an area of 5 meters (diameter).
    - **Crowd position:** The crowd will be located behind the robot at a distance between 2 and 3 meters apart.
5. **Find the operator:** Once the crowd has been located, the robot must greet the operator and state the gender, and pose (sitting, standing, rising arms, etc.). Also, it must point or approach to the operator.
    I found you operator. You are the smiling girl sitting in the middle of the crowd.
6. **Describe the crowd**: Finally, robot must tell the size of the crowd and how many men, women and even children are.

5.4.5 Additional rules and remarks

1. **Preparation:** The robot needs to wait for at least 1 min before the operator appears in front of the robot. During this waiting time the team is not allowed to touch the robot.
2. **Disturbances from outside:** If a person from the audience (severely) interferes with the robot in a way that makes it impossible to solve the task, the team may repeat the test immediately.
3. **Instruction:** The robot interacts with the operator, not the team. That is, the team is not allowed to instruct the operator.

5.4.6 OC instructions

2 hours before the test

- Select the "professional" operator(s).
- Select the crowd.

During the test

- Check save operation of the robot; the robot needs to be stopped immediately if a person is going to be touched by the robot

5.4.7 Score sheet

The maximum time for this test is 5 minutes.

Action	Score
Operator	
Approach or point at the operator	3.0
Correctly state operator's gender	3.0
Correctly state operator's pose	3.0
Crowd	
Correctly state crowd's size	2.0
Correctly state crowd's number of men	2.0
Correctly state crowd's number of women	2.0
Total score (excluding penalties and bonuses)	15.0

5.5 RoboZoo

The robots of all teams are presented and arranged in a way that all of them form a zoo-type corridor through which the general audience will walk. Each robot is enclosed within a space that it cannot get out of, and it must perform a show for up to one hour, such as dancing or carrying out any menial task. Each member of the audience who enters the corridor will receive 5 tokens which will be given to his/her top 5 favorite robots. The robot who earns the most tokens wins the contest and gets the maximum score. Points are awarded to the other robots based on the amount of tokens they gathered, proportional to the amount of tokens gotten by the robot that won the contest.

Interaction with the audience is desirable but not mandatory.

5.5.1 Enclosed Space Dimension

The enclosed space is estimated to be around 2×2 meters. However, teams should expect reasonable deviations in these dimensions, since space in the venue may require smaller enclosed spaces.

5.5.2 Security Concerns

Security is first priority in this competition. To this effect, one team member is required to be inside the enclosed space to ensure that the robot is performing securely. Physical interaction between audience members and the robot is not allowed (i.e. robot handing things to people or shaking hands). Interactions such as talking to the robot, or carrying out face recognition are allowed. To not limit the creativity of the teams in their demonstrations, the robot may hand-out items to the public via using the one team member inside the enclosed space as a type of proxy. In addition, persons from the general public are not allowed inside the enclosed space at any moment.

Important Note: Even if people is not allowed to enter the robots' cages, it may happen people (specially small children) get into the cages. In those cases, robot must be shut down immediately.

5.5.3 Restart and Charging

If the robot requires a restart, the one team member inside the enclosed space may tend to it and restart it as much times as required. However, it is important to note that this test is essentially scored by the general public, and it is reasonable to expect that the audience will not be attracted to a robot being constantly fixed. In addition, since this test may last up to one hour, the robot may require a change of batteries or to use a charging station, which is allowed. However, as pointed out before, this may not be attractive to the audience, so it is recommended to reduce the charging necessities to a minimum.

5.5.4 Additional rules and remarks

- **Gifts:** Robots and team member are *not* allowed to hand out gifts as part of the RoboZoo challenge.

- **Protagonist robots:** Robots must be able to perform autonomously during the test. Team members are *not* allowed to interact with the audience, teach instructions, take part of the show, etc. In the case that team members are lurking around the cages or interacting with the audience, that team will be disqualified.
- **People in the cage:** At any time, one team member must be inside the cage to take care of the robot. More than one team member inside the cage is *not* allowed.

5.5.5 OC instructions

2h before test:

- Announce to teams the dimension of the enclosed spaces.
- Specify where the presentation will take place.
- Specify which space will be occupied by which robot.

5.5.6 Score Sheet

The maximum time for this test is 60 minutes.

Robots are scored on functionality and on design. The audience can awards tokens for what they elect to be the **Most functional robot** and the **Best looking robot**.

Action	Score
Appearance	$2.5 \times \frac{best}{this}$
Performance	$2.5 \times \frac{best}{this}$
Special penalties & bonuses	
Not attending 3.7.1	-5
Outstanding performance 3.7.3	1
Total score (excluding penalties and bonuses)	**5**

Normalization: The teams with less tokens than the best team get proportional score based on the number of tokens they received, e.g score for this team $= 2.5 \times \frac{t_{this}}{t_{best}}$ where t_{this}, t_{best} is the number of tokens received by this team, and the number of tokens received by the best team.

5.6 Speech Recognition & Audio Detection Test

This test is divided in two phases. First the robot must answer a set of questions to an operator at the first attempt without asking for confirmation. The operator is not allowed to move to the robot or shout to the robot.

For the second phase, the Operator will move behind the robot and ask a set of questions which the robot must answer. The robot is allowed to turn to the operator and ask it to repeat the question, and the operator will repeat the question only once before moving again behind the robot and proceed with the next question.

5.6.1 Goal

The robot must be able to properly recognize and answer to a specific set of questions without ask for confirmation. Also, the robot shall be able to react to a speaking operator which is not facing to it.

5.6.2 Focus

This test focuses on voice recognition and audio-source localization in a noisy environment, with moving sound sources[2].

5.6.3 Setup

1. The apartment is in its normal state.
2. All doors of the apartment are open, except for the entry door.

5.6.4 Task

1. **Direct speech recognition:**   The robot should move (or be moved) to a previously specified point inside the arena. A TC member will ask 5 questions from the set of 25 predefined questions in front of the robot. The robot should answer the question without asking confirmation.

   - The operator shall be standing still and facing to the robot.
   - The operator shall be between 0.75 and 1.0 meters away from the robot position.
   - The operator shall be between -60 and 60 meters from the robot's center (front range).

2. **indirect speech recognition:**   A TC member will ask another 5 question of the same set, but standing outside the front range of the robot at the same distance. The robot should turn towards the speaker and answer the question.

   - The robot may answer the question without asking confirmation nor turn towards the operator.
   - The robot may ask for only one repetition of the question but only after turning toward the operator.

---

[2]This test may also be held outside the arena

5.6.5 Additional rules and remarks

- **Continue rule:** Continue rule (Section 3.6.15) can not be used during this test.
- **Question timeout:** If the robot does not answer within 10 seconds, the question is considered as *missed*, and the TC member will proceed with the next question.

5.6.6 Referee instructions

The referee needs to

- avoid shouting to the robot
- avoid getting closer to the robot
- Speak to the robot loud and clear with plain standard English.

5.6.7 OC instructions

1 day before the test

- Provide the set of 25 predefined questions

2 hours before the test

- Announce the placement of the robots

5.6.8 Score sheet

The maximum time for this test is 5 minutes.

Action	Score
Operator within the front range	
Correctly answered question	5×1.0
Operator outside the front range	
Correctly answered question (first attempt)	5×2.0
Correctly answered question after asking operator to repeat (second attempt)	5×1.0
Total score (excluding penalties and bonuses)	15.0

Chapter 6

Tests in Stage II

All ability and integration tests in Stage II grants 25 points (but the Open Challenge which grants 20) and are performed only once. Some tests –like Wake-me-up Test– have optional tasks that grant additional points when performed correctly, clean and fast. TC must be informed if a team is planning to perform any of the optional tasks. No additional time is given while performing optional tasks.

In the Open Challenge the robot must be able to show to the Technical Committee the achievements on the main research line of it's own team. This test grants up to 20 points.

6.1 Open Challenge

During the Open Challenge teams are encouraged to demonstrate recent research results and the best of the robots' abilities. It focuses on the demonstration of new approaches/applications, human-robot interaction and scientific value. To participate in this test it is required to participate in any other test from Stage II.

6.1.1 Task

The Open Challenge is an open demonstration which means that the teams may demonstrate anything they like with an high difficulty degree. The performance of the teams is evaluated by a jury consisting of all members of the technical committee.

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

1. **Setup and demonstration:** The team has a maximum of seven minutes for setup and demonstration. During the demonstration, the robot must perform at least 1 complex task (see Section ??for a list of examples on each category), preferably including Human-Robot interaction or a Smart House environment, to be evaluated by the Technical Committee. During Setup Time and before the demonstration begins, the team leader is allowed to *very* briefly the address the problem and the demonstrated approach (maximum time is one minute).

   1.1. If available, video projector or screen may be used to visualize robot's internals, e.g., percepts.
   1.2. It is important to note that the jury may decide to end the demonstration if there is nothing happening or nothing new is happening.

2. **Interview and cleanup:** After the demonstration, there is another three minutes where the team answers questions by the jury members.
   During the interview time, the team has to undo its changes to the environment.

6.1.2 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.

6.1.3 Jury evaluation

The jury is constituted of members of the technical committee. Evaluation is based on the following criteria:

1. Overall demonstration
2. Scientific contribution (Is that new in @Home?)
3. Robot autonomy in the demonstration
4. Difficulty of the performance (How difficult is it?)
5. Success of the performance (The robot did it?)
6. Contribution for @Home (can other teams use the solution?)

6.1.4 Additional rules and remarks

1. **Start signal:** There is no standard start-signal for this test.
2. **Abort on request:** At any time during the demonstration, the jury may interrupt and abort the demonstration:

   2.1. if nothing is shown: in case of longer delays (more than one minute), e.g., when the robot does not start or when it got stuck;
   2.2. if nothing new is shown: the demonstrated abilities were already shown in previous tests (to avoid dull demonstrations and push teams to present novel ideas).

3. **Team-team-interaction:** An extra bonus of up to 500 points can be earned if robots from two teams (4 robots maximum, 2 from each team) successfully collaborate (robot-robot interaction).

   3.1. This bonus is earned for both teams.
   3.2. The robot(s) of the other team must only play a minor role in the total demonstration.
   3.3. It must be made clear that the demonstrations from the two teams are not similar, otherwise the points cannot be awarded.
   3.4. In case a team receives two (or more) bonuses, the maximum bonus will be taken.
   3.5. The collaboration is possible even if one of the two teams has not reached Stage 2.
   3.6. The team which does not participate in Stage 2 receives no points for this test.

6.2 Restaurant

The robot is tested in a real environment such as a real restaurant or a shopping mall.

6.2.1 Focus

This test focuses on online mapping, safe navigation in previously unknown environments, gesture detection, human-robot interaction, and manipulation in a real environment.

The robot will need to create it's own map from the environment an then move into it to handle human requests, such as delivering drinks or snacks, while people are walking around.

6.2.2 Setup

1. **Location:** A real restaurant fully equipped with a "Professional Waiter" and at least three tables with "Professional Clients".

6.2.3 Task

1. **Guide phase:** Starting from the *Kitchen*, the robot is guided through the environment by a "Professional Waiter" which shows to the robot the location of each of the tables, it's number, and on which side the table is (there is a total of 3 tables). After visiting all the tables, the robot must be guided again to the *Kitchen*.

   - **Own *Professional Waiter* [Optional]:** Team Leader may choose to use their own custom *Professional Waiter* for this test instead of the one provided by the committee. The Team Leader must inform a TC member at least one hour before the competition. When using a custom *Professional Waiter*, no points are earned for state the side of the table.
   - **Finding the tables [Optional]:** Team Leader may choose not to tell the robot on which side (left or right) is the table, and let the robot find the tables by itself. When using this option, the robot must state where the table is (i.e. by telling: *the table is to my right*).

2. **Ordering phase:**

   2.1. **First order (Table A):** Once in the kitchen, the robot shall ask to the *Professional Waiter* to which table go first to take an order from. The robot has to go to the indicated table and ask for an order.
   2.2. **Detecting a call (Table B or C):** At any time while attending Table A guests (going to fetch an order, asking the client, or returning to the kitchen with the order), a guest in Table B or C will wave to the robot asking for his attention. Robot must state loud that it has detected the call and will attend as soon as possible.
   2.3. **Second order (Table B or C):** After taking the Table A client's order, and if the request was detected, the robot must go to the table of the waving person and ask for an order.
   2.4. **Avoiding random citizen:** At any time while going to any of the tables or to the *Kitchen*, a person may step on the robot's path. It is expected the robot to avoid that person or stop and wait for it to move away.

Orders: The menu offers Beverages and Combos (e.g. a steak with fries, hamburger with fries, steak with vegetables, hamburger with vegetables, etc.). An order may be a Beverage or Combo. One guest will order a Combo while the other will order a Beverage.

Note: Table A, B and C may be any of Table 1, 2, 3, ..., N in any order.

3. **Delivering phase:**

   3.1. **Repeating the order:** Once again in the kitchen, the robot recites the orders for each table, including the table number (e.g. *Hamburger with fries for table 1 and Orange juice for table 2*). This includes determining the table number of the waving person.

   3.2. **Delivering Beverage:** The robot must grab a can of the appropriate drink from a set of cans on the bar and deliver it to the correct table.

   3.3. **Delivering Combo:** The robot must carry a plate with the ordering to the table the food was ordered from. Teams must indicate beforehand whether the robot is able to grasp the plate itself, whether it needs a tray or whether the plate needs to be handed to the robot.

4. **Next customer, please:** The task is finished when the robot has delivered both orders and is back at the kitchen.

6.2.4 Additional rules and remarks

- **Safety!** This test takes place in a public area. That is, there may be people standing, sitting or walking around the area throughout the test. The robot is expected to not even slightly touch anything and is immediately stopped in case of danger.
- **Referees and guidance:** For safety reasons, the referees in this test are TC members. One of the referees follows the robot and is always in reach of the emergency button.
- **Start:** There is no fixed start signal in this test.
- **Order:** The way the user provides such information to the robot is up to the robot's team.
- **Location:** This test can be arranged in any real restaurant or shopping mall. If this is not possible, the test can be conducted in an arbitrary room containing the appropriate locations. The only requirement is that this room is not part of the arena and that the teams do not know the room beforehand. The exact location, including the object and delivery locations, will be defined by the technical committee on site (and in corporation with the local organization).
- **Natural walking:** The operator has to walk "naturally", i.e., move forward facing forward. If not mentioned otherwise, the operator is not allowed to walk back, stand still, signal the robot or follow some recalibration procedure.
- **Disturbances from outside:** If a person from the audience (severely) interferes with the robot in a way that makes it impossible to solve the task, the team may repeat the test immediately.

6.2.5 Score sheet

The maximum time for this test is 10 minutes.

Action	Score
Training phase	
Learning the location of a table (Professional Waiter)	3×1.0
Learning the location of a table (Custom Waiter)	3×0.5
Inferring the side on which a table is (Professional Waiter only)	3×1.0
Ordering phase	
Understanding which table to take an order from	0.5
Going to the designated table	1.5
Taking an order from the designated table	1.0
Noticing a waving person from distance	2.0
Going to the table of the waving person	2.0
Taking an order from the waving person	1.0
Avoiding a person crossing the robots' path	1.0
Delivering phase	
Reciting both the order and table number for both tables	2×0.5
Grasping the correct drink	1.0
Getting close to the correct table with the drink	1.5
Delivering the drink by placing it on the correct table	1.5
Picking up the plate	1.5
Getting close to the correct table with the plate	1.5
Delivering the plate by placing it on the correct table	2.0
Total score (excluding penalties and bonuses)	25.0

6.3 Robo-Nurse

The robot is assisting an elderly person with getting her pills and responding to observed activities.

6.3.1 Focus

This test focuses mainly on Human-Robot Interaction and Activity Recognition.

6.3.2 Task

1. **Move to the patient**: The patient (lets call her Granny) calls for robot assistance using her voice or by waving arms.
2. **Asking for pills**: Granny asks the robot for her pills which are in bottles located on a shelf nearby.
3. **Describe and choose pills**: On the shelf, there are multiple bottles with pills and the robot must asks Granny which bottle she needs.

   - The robot must indicate what bottles are on the shelf by briefly describing each bottle. **the faster the robot starts describing (i.e. finished recognizing) after arrival (standing still in front of the shelf) at the shelf, the better: faster recognition gives more points.**
     - "The leftmost ones"
     - "The *color* bottle"
     - "The big/small bottle"
     - Any other description the robot understands and spoke out loud to Granny. E.g. if a robot can do text recognition and read each label to Granny, she may reply with e.g. "Asperine".

   - **Grasp & handover pills**: The robot must grasp the indicated bottle of pills and hand them over to Granny. The handover to Granny must be "natural", without a voice confirmation of when to let the pills go etc. Granny will take the pills from the robot's hand and the robot must open its hand.

   - **Activity Recognition**: One of the activities below happens and the robot must act accordingly:
     - **Drop blanket**: Granny's stands up and sits doen immediately. Her blanket falls over her lap on to the ground. The robot must **pick up the blanket** and hand it to Granny
     - **Fall**: Granny stands up from her chair and falls. The robot must **hand Granny a phone** or use the Smart Home for that. The phone will be laying on the coffee table in the living room.
     - **Walk and sit**: Granny walks to a table with her walking stick/cane. Robot must follow and take walking stick from Granny after she sits down an a chair closeby.

6.3.3 Additional rules and remarks

3.1. **Continue Rule:** The CONTINUE rule may be applied several times in the Conversation part of the test (Section 3.6.15).

3.2. **Make it fast:** Description of objects should be fast, as is reflected in the scoring.

6.3.4 Referee instructions

The referee needs to

- Place the bottles on the shelf.
- Lay the phone on the coffee table.

6.3.5 OC instructions

2 hours before the test

- Announce the room where the patient is

During the test

- Instruct Granny which pills she wants.
- Instruct Granny which of the 3 actions to perform.

6.3.6 Score sheet

The maximum time for this test is 10 minutes.

Action	Max. score
Move to the patient after voice call or waving	2
Await command to get pills.	1
Describe pills. Speed is important: 4 points can be gained if the robot starts speaking immediately after arriving at the shelf; 3 points if within 5 seconds, 2 with 15 seconds and 1 if within 30 seconds. No points are gained when the information given by the robot to Granny is incorrect.	4
Choose pills	4
Grasp pills	2
Handover pills. The robot must not instruct Granny when to take hold of the pills: the robot must release the bottle when Granny takes them from the robot's gripper. Only 1 point will be awarded when instructions are needed.	2
Activity recognition	
Drop blanket	5
Fall	5
Walk & sit	5
Response to activity	
Pickup and give blanket	5
Grasp phone	5
Take cane	5
Total score (excluding penalties and bonuses)	25

6.4 Wake me up test

The robot's owner has overslept. Knowing the schedule of the owner and noticing it is getting late, the robot helps it's owner to wake up and start the day.
The robot has to help a human in a daily morning task. The task involves interact with a smart house, awake a dormant human, take an order, prepare the breakfast and deliver it to the human.

6.4.1 Focus

This test focuses on advanced object manipulation, human pose detection, object recognition and and manipulation; as well as object recognition.

6.4.2 Task

3.1. **Awakening the owner:** The robot enters the bedroom, approaches to the bed, and starts to awaken the owner (operator lying on the bed) for one minute by playing an alarm-like sound or using it's own voice. Within one minute starting from the first call, the owner will wake up in a natural way (sit on the bed and rub face; sit on bed, rise arms and yawn; stand up etc.), then the robot must announce it has successfully detected the awakening by greeting it's owner.

  - **Turning-on bedroom's lights [Smart-house option]:** After entering to the bedroom, the robot can send a command to the house to turn on the bedroom lights.
  - **No annoying sounds:** Alarm-like sounds must be short and clean (no continuous music is allowed), and voice calls must be short and clear. A silence gap of 10 seconds between calls is advised.
  - **Show must go on:** One minute after the first call, the owner is awake, so the robot must proceed to the next point.

3.2. **Delivering the newspaper [Optional]:** After awakening it's owner, the robot approaches to her and delivers a newspaper into the owner's hand (the owner will face the robot after being awakened and extend her hand to it). Robot must release the newspaper only after the human has grasped it.

3.3. **Taking breakfast order:** The robot asks to it's owner for a breakfast of her preference. The order will include: one random fruit/snack, one kind of cereal, and one kind of milk (stating no milk means whole milk), but those can be given in any order. The robot may ask for a confirmation of the order up to three times. If the robot is not able to handle a tray (see below), it must state that breakfast will be delivered to the dining room. Examples of the order are:

  - Froot-loops with banana and light milk.
  - Flakes with lactose-free milk and a peach.
  - Apple and choco-flakes (i.e. one apple, and choco-flakes with whole milk).

3.4. **Opening kitchen's door [Optional]:** The kitchen's door is closed. Upon arrival, robot has 1 minute to open the door. It may also give up and request for the door to be opened by a referee.

3.5. **Turning-on kitchen light [Smart-house option]:** After entering to the kitchen, the robot can send a command to the house to turn on the kitchen lights and the coffee brewer. Kitchen lights must be turned on every time the robot enters the kitchen.

3.6. **Serving the breakfast:** Once in the kitchen, the robot must locate the tray and place into it the requested fruit/snack, a box of the requested type of milk, and a bowl; then pour the requested type of cereal into the bowl. If the robot is not capable of handling a tray, it may serve the breakfast directly at the diner table. The placement order is not relevant.

3.7. **Placing the spoon [Optional]:** After placing the cereal bowl on the tray or dining room table, the robot may place a spoon close to it. Delivering the tray: After placing objects into the tray, the robot must take the tray and deliver it to the human in the bedroom, leaving it on a table or directly to the owner's hands.

3.8. **Turning-off kitchen light [Smart-house option]:** After leaving to the kitchen, the robot can send a command to the house to turn off the kitchen lights. Kitchen lights must be turned off every time the robot leaves the kitchen.

3.9. **Doing the bed [Optional]:** After the breakfast has been delivered, the robot may proceed to do the owner's bed. Points are awarded based on a "Professional Mom" criteria.

6.4.3 Additional rules and remarks

- **Smart-house:** The arena-house may have enabled official smart-house devices (Section Section 3.2.10), there are additional scoring for interacting with the house.
- **Optional tasks:** The test includes optional tasks (such as deliver the newspaper, placing the spoon, and doing bed) which are not required to be performed as part of the overall test but brings an additional scoring for solving it. Team leader must contact a TC member to request optional tasks to be available.
- **Fruit or snack?:** If the robot is not able to properly handle fruits, it can be replaced by easier-to-manipulate objects from the official object list. Team leader must contact a TC member to request using snacks instead of fruits.
- **Two robots:** This is a very challenging test and serving the breakfast is complex and time-consuming task. If a team has more than one robot, up to two robots may collaborate in the "serving the breakfast" and "delivering the tray" tasks. Team leader must contact a TC member to inform there will be two robots in the arena.
- **Collaborative test:** The team leader may request help from a second team to perform the "serving the breakfast", "delivering the tray" tasks, and "smart-house" optionals. All score achieved by both robots is given to the main team, but also the points scored by the helping-robot are given to the helping team as a bonus. This cooperation must be informed to the TC at least two hours before the competition.

6.4.4 Referee instructions

The referee needs to

- Give a wake-up signal to the operator within a minute starting from the robot started to call her

- Generate and provide a random breakfast order for the operator
- Type the breakfast order in a qualified typing device when required (Continue rule, Section Section 3.6.15).
- Stop the robot immediately when tray is about to fall

6.4.5 OC instructions

2 hours before the test

- Announce the placement of the objects
- Announce the placement of the tray

During the test

- Provide teams with the newspaper
- Place tray and breakfast objects into the kitchen
- Place spoon when needed

6.4.6 Score sheet

The maximum time for this test is 10 minutes.

Action	Score
Awakening the human	
Detect the human awakening	2.0
Taking the order	
Understanding whole order	2.0
Understanding whole order on console (typed)	0.5
Robot's own suggestion for breakfast	0.0
Serving breakfast	
Placing the bowl	2.0
Placing the milk bottle (score on wrong milk type)	1.0
Placing the fruit/snack (score if using snack instead of fruit, score on wrong object type)	2.0
Pouring cereal into the bowl (score on wrong cereal type)	3.0
Spilling cereal outside the bowl	-1.0
Spilling much cereal outside the bowl	-2.0
Delivering breakfast	
Grasping the tray (and successfully lifting it up to at least 5 cm for more than 10 second)	3.0
Safely transporting the tray (no object inside flipped or fell during transport)	1.0
Placing the tray (safely and the tray stands still for more than 10 second)	2.0
Handing-over the tray to the operator's hands	4.0
Complete the task with complete and correct order	2.0
Smart-House optionals	
Turning on bedroom lights on enter	1.0
Turning on kitchen lights and coffee brewer on enter	1.0
Turning off kitchen lights on leave	1.0
Optional tasks (up to 20 points)	
Handing-over the newspaper	2.0
Opening kitchen's door	5.0
Placing the spoon	3.0
Doing bed	10.0
Total score (excluding optional tasks, penalties, and bonuses)	25.0

Chapter 7

Finals

The competition ends with the Finals on the last day, where the five teams with the highest total score compete. The *Finals* are conducted as a final open demonstration where the robots show their best abilities. This demonstration does not have to be different from the other open demonstration —open challenge— nor have to be the same either.

7.1 Final Demonstration

In the final demonstration, every team qualified for the finals can choose freely what to demonstrate. The demonstration is evaluated by both a league-internal and a league-external jury, considering also the score during the competition.
It is intended to show that a robot is able to perform a set of advanced skills integrated into a simple story driven at home. The story, in which the robot is the main character, must be easy to understand and self explicative.

7.1.1 Task

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

3.1. Setup and demonstration: The team has a maximum of ten minutes for setup and demonstration. During the demonstration, the robot must perform at least 2 complex tasks from different categories (see Section ??for a list of examples on each category) to be evaluated by the League-internal jury. During Setup Time and before the demonstration begins, the team leader is allowed to *very* briefly describe the story (maximum time is one minute).

3.2. Interview and cleanup: After the demonstration, there is another five minutes where the team answers questions by the jury members. The team may prepare one slide with technical information of the task to rely on during the interview in case that projectors are available.
During the interview time, the team has to undo its changes to the environment.

7.1.2 Evaluation and Score System

The demonstration is evaluated by both a league-internal and a league-external jury. The final score and ranking are determined by the two jury evaluations and by the previous performance (in Stages I and II) of the team.

3.1. 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:

3.1..1. Scientific contribution (Is that new in @Home?)

3.1..2. Performance executing complex skill 1

3.1..3. Performance executing complex skill 2

3.1..4. Contribution for @Home (can other teams use the solution?)

3.1..5. Performance executing each additional complex skills (if any, scoring as bonus)

It is expected that teams present their scientific and technical contributions in the team description paper . In addition, finalist teams may provide a printed document to the jury (max 2 pages) that summarizes the demonstrated robot capabilities and contributions.

The influence of the league-internal jury to the final ranking is 25%.

3.2. 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:

3.2..1. Integration of skills in story (story-telling is to be rewarded)

3.2..2. Difficulty of the performance (How difficult is it?)

3.2..3. Success of the performance (The robot did it?)

3.2..4. System integration (How smooth was the execution?)

3.2..5. Relevance / Usefulness for daily life (I want that robot in my home!)

The influence of the league-external jury to the final ranking is 25%.

3.3. Previous performance: 50% of the final score are determined by the team's previous performance during the competition, i.e., the sum of points scored in Stage I and Stage II.

7.1.3 Changes to the environment

3.1. 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.

3.2. 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.

7.1.4 Final Ranking and Winner

The winner of the competition is the team that gets the highest ranking in the finals
There will be an award for 1st, 2nd and 3rd place. All teams in the Finals receive a certificate stating that they made it into the Finals of the RoboCup@Home competition.

Appendix A

Example Skills

The following section presents a list of *Example Skills* with an high degree of difficulty which can be exploited during the *Open Demonstrations* (See Section 3.5.5. Other skills not on this list (yet) may be added as well. If you want to do so, please let the TC know via email (tc@robocupathome.org) for their inclusion on the RuleBook so all teams may also show this skill.

Please note that these examples are to illustrate the level of complexity and applicability that should be shown. For instance, "Handle a pan" is listed in the category of *Complex manipulation*, but it is extensive to handling pans, pots, woks and any other cookware with handles.

A.1 Skills by category

A.1.1 Complex manipulation

- Cook a meal.
- Manipulating panels/switches/knobs.
- Use/open a fridge/stove/blender/microwave/washing machine.
- Iron clothes.
- Move a movable object (pole, chair, table).
- Pouring liquids/powders.
- Operate a water tap.
- Handle a pan.

A.1.2 Complex vision

- Read text from a newspaper.
- handle glass/shiny-metallic objects.
- Recognize moods, activities, age, gender.
- Label unknown objects.

A.1.3 Complex navigation

- Navigate on (very) crowded environments.
- Navigate difficult terrain.
- Climb stairs.
- Push a wheelchair.

A.1.4 Robot-Human Interaction

- Collaborative robot-human manipulation.
- Maintaining a conversation.
- Learning actions on-the-fly.
- Learning objects from humans.
- Following a human by grasping it's hand.
- Explain the robot abstract concepts (why people love sunny days).
- Arrange unknown random people for a nice photo (no occlusions).

A.1.5 Complex action planning

- Separate clothes for laundry (e.g. by color)
- Arrange a dish-washer.
- Take a cup from the cupboard whose location has changed, is closed, or the path to it is blocked (e.g. by a chair).
- Light the way out with a lamp during a general power off.
- Arrange unknown random people for a nice photo (no occlusions).

Abbreviations

Index