

CYBATHLON Challenges 2023

RACES & RULES



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Version 1.03

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1 Additional Information

1.1 Version Management

1.1.1 Version Overview

Version	Comments	Date	Responsible	Status
1.0	This version defines the disciplines, tasks and rules for the CYBATHLON Challenges in 2023. Changes from the Races & Rules for CYBATHLON 2024 V 3.0.2 were highlighted in orange.	30 Sep 2022	Lukas Jaeger	completed
1.01	Changes are marked blue. Typos corrected. Rules clarified. Missing information added. Redundant rules deleted. Some task names changed. WHL: The order of the task is changed. New: Doorsteps - Crowd.	20 Jan 2023	Roland Sigrist	completed
1.02	Changes are marked blue. Rules clarified. Missing information added. New rendering VIS sidewalk. Former ROB-4 deleted. New renderings ARM, ROB, VIS, WHL.	28 Feb 2023	Marionna Munger	completed
1.03	Changes since 1.01 are marked blue. Minor changes for ROB (in ROB-6, ROB-CLEAN-3, GR-31 & GR-33). Link to appeals document added.	20 March 2023	Marionna Munger	completed

Document versioning

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RACES & RULES, CYBATHLON Challenges 2023

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2 Introduction

CYBATHLON Challenges are a new competition format on the Road to CYBATHLON 2024 to give the teams and their pilots the opportunity to test their devices, to showcase their developments, and to gauge their performance against that of other teams.

The competition format of the CYBATHLON Challenges is very compact and straight forward: a limited number of teams, one to two tasks from the Races & Rules of CYBATHLON 2024 in selected disciplines and each participating team has one to two attempts to solve the task(s).

3 General definitions & rules







3.1 Definition of terms

- Team: An entity with the goal to develop an assistive device and to participate in a CYBATHLON competition.
- Team official: Accredited member of a team (e.g., pilot, team manager, support person) who contributes to the development of the assistive device or to the participation of the team in a CYBATHLON competition.
- Team manager: Team official who is responsible for the overall organisation and management of a team in a specific discipline.
- Pilot: Team official meeting the eligibility criteria and participating in the races of a specific discipline.
- Backup pilot: Team official meeting the eligibility criteria who takes the role of the pilot if the (primary) pilot drops out or withdraws from participation.
- Support person: Team official with specific expertise who supports the team in a specific area (e.g., technician, communication specialist, therapist).
- Care person: Team official who is a member of the pilot's social network who helps with activities of daily living.
- Assistive device: A technical unit designed and developed to assist a person with a disability to perform specific tasks.
- Technology provider: Person or legal entity that provides the assistive device developed for and used in a specific discipline. The technology provider can be a research laboratory, a company, or a private individual. The technology provider is usually also the developer of the assistive device.
- MedCheck: A predefined process designed to systematically verify that pilots fulfil the general and discipline-specific eligibility criteria and to ensure that participation is safe from a medical perspective. The MedCheck is conducted by neutral medical examiners appointed by the CYBATHLON organising committee who will keep the provided information confidential.
- TecCheck: A predefined process designed to systematically verify that an assistive device fulfils the general and discipline-specific eligibility criteria, and to examine the risks for the pilots and their environment related to the use of the assistive device. The TecCheck is conducted by neutral technical examiners appointed by the CYBATHLON organising committee who will keep the provided information confidential.
- Spotter: A team official to prevent the pilot from falling, to help them to move or leave the track during the race. A spotter is trained to only intervene in case of an imminent risk to the pilots or their environment.

- Referee: CYBATHLON official at a competition hub who is responsible for judging the behaviour of the pilot during task execution and enforcing the general and task specific rules during a race run.
- **Timekeeper Scorer**: CYBATHLON official at a competition hub who is responsible for **scoring the task (according to the decision of the referee) and** measuring the time it takes the pilot to attempt the competition tasks during a race run **with the results system mobile app.**
- Competition task: Single stage of a racetrack reflecting a specific daily life challenge of a given discipline. Each task is defined by a set of infrastructure, a task space, and a set of rules. The rules define the criteria for successful completion or failure of task execution.
- Race run: A timed attempt of a single pilot to solve the entire set of competition tasks of a given discipline.
- Competition: The entirety of all races of a given discipline.
- Race direction: The most direct route between start and finish line.
- Task infrastructure: all elements defining a task
- Task objects: Parts of task infrastructure that must be manipulated by the pilot to solve a task.
- Callroom: Room where pilots and accompanying persons wait before going to the startline of the race. In the callroom, the sight to the racetrack is blocked.

3.2 Competition disciplines

The CYBATHLON Challenges competition in 2023 consists of the following six disciplines:

Discipline Name	Discipline abbreviation	Discipline icon
Arm Prosthesis Race	ARM	
Leg Prosthesis Race	LEG	
Exoskeleton Race	EXO	
Wheelchair Race	WHL	
Vision Assistance Race	VIS	
Assistance Robot Race	ROB	

Overview of CYBATHLON competition disciplines

3.3 General Rules

The following General Rules (GR) apply to all CYBATHLON disciplines:

GR-1 A team must consist of a technology provider and a pilot. Further team officials are allowed. Each team must be managed by a team manager.

Comment on GR-1: The team manager and the pilot can be the same person. The team manager and the technology provider can be the same person.

GR-2 A team and its team officials must meet the conditions outlined in the team registration section of the CYBATHLON website.

GR-3 A team can only participate in one discipline. Only one pilot can participate per team per discipline.

Comment on GR-3: To compete in several disciplines, the same institution can register more than one team.

GR-4 Teams shall provide their pilot(s) with sufficient training of the competition tasks prior to a competition to make sure that they are accustomed to the tasks.

3.4 General competition rules

GR-5 Pilots must use their dedicated assistive device for the entire duration of the competition. I.e., the assistive device may not be used by other pilots during the same competition.

GR-6 It is not allowed to exchange pilots (i.e., pilot and back-up pilot) between different race runs of the same competition.

GR-7 It is not allowed to exchange the assistive device (or components thereof) or to modify its function during the competition. Maintenance or repair using identical spare parts is allowed. Minor adjustments that do not affect the basic functions or safety of the assistive device (e.g., change the gearing of a FES bike) are allowed after the assistive device has passed the TecCheck – as long as the parts used for these adjustments have been declared in and passed the TecCheck.

GR-8 Between race runs, any team official can maintain or replace components of the assistive device. If components are replaced, only identical replacement parts must be used.

GR-9 All components (e.g., batteries, control units, tools, spare parts) that are used during a race run must be carried by the pilots from the start to the

end of the race run. All components must be listed in the description of the assistive device handed in for the TecCheck.

- GR-10 During a race run, only the pilots may maintain or replace components of their assistive device.
- GR-11 During a race run, direct or remote control of the assistive device by any person other than the pilot is not allowed.
- GR-12 Wireless communication between components of the assistive device is allowed. Wireless communication between the assistive device and computers beyond the race run (e.g., local computer, server or similar) is allowed provided that the communication is only used for data monitoring, recording or emergency shutdown of the assistive device. It is allowed to connect to the internet. All websites and web services must be listed in the description of the assistive device handed in for the TecCheck.
- Comment on GR-12: A competition site (competition hub) does not guarantee stable internet connection. Finding access to the internet is a matter for the teams.
- GR-13 During a race run, the pilot must not be supported by another person or a service animal (e.g., a service dog) in solving tasks or parts thereof.
- Comment on GR-13: Cases in which a pilot must be accompanied by another person or a service animal for medical reasons will be assessed by the organising committee individually.
- GR-14 During a race run one team official can travel alongside the pilot on the competition field in a dedicated area (accompanying person). Unless otherwise specified in a rule of a specific discipline, the accompanying person can verbally interact with the pilot (e.g., for coaching). In case of any physical intervention of the accompanying person with the assistive device (e.g., in case of a technical defect or an emergency) the race run is terminated for that pilot. The pilot's current score is then taken as the score for that race run (see also GR-35).
- GR-15 Radio communication between the pilot and any team official or any other person is not allowed during a race run.
- GR-16 In certain disciplines, spotters must supplement the general safety precautions during the race run. Spotters are allowed to touch the pilots or devices, but not to physically support the pilots. The task is failed if a spotter physically supports a pilot.

GR-17 Pilots must be ready for their race run at the time and location communicated by the CYBATHLON organising committee. If not, the pilot is not allowed to start the race run.

GR-18 Pilots must be prepared to start their race run when instructed to do so. Any undue delay results in the disqualification from the race run.

3.4.1 ARM, LEG, EXO, WHL, VIS, ROB

3.4.1.1 Competition infrastructure

GR-19 The race runs take place on a racetrack that consists of two discipline-specific tasks. The area of each task (task space) is defined by a start line, two sidelines and a finish line. These lines must be perpendicular to each other.

GR-20 The length of a task is 5.00 ± 0.005 m. The width of a task is 2.95 ± 0.005 m.

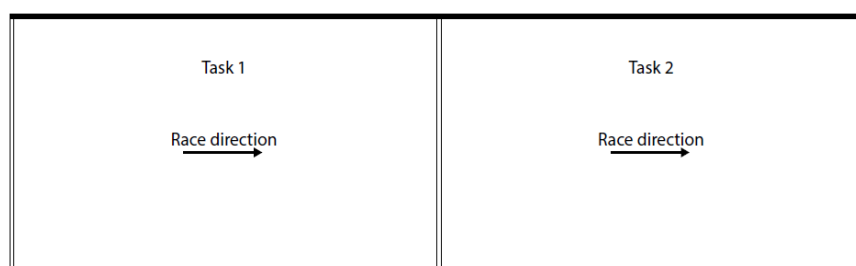
Comment on GR-20 The task space needs to be represented, also if a team at a local hub decides to skip a task. The obstacle does not need to be built or set up if the task is skipped.

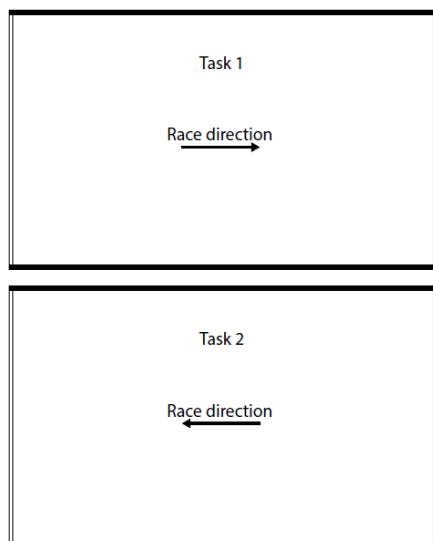
GR-21 The start and the finish line as well as the sidelines of a task must stand out clearly from the ground.

Comment on GR-21: Guidance lines with a height of 2-3 mm are installed along the sidelines and at the start and finish line of the task to support orientation on the racetrack in the Vision Assistance Race. If the same base track is used for other disciplines, these guidance lines remain.

GR-22 At a given competition site, the elements of the competition tasks must be built up on an even and solid surface. Additional flooring may be used.

GR-23 The tasks are set up in a predefined order. The racetrack can be set up in two possible layouts, depending on the space available at the competition venue:





The two possible layouts for setting up the tasks.

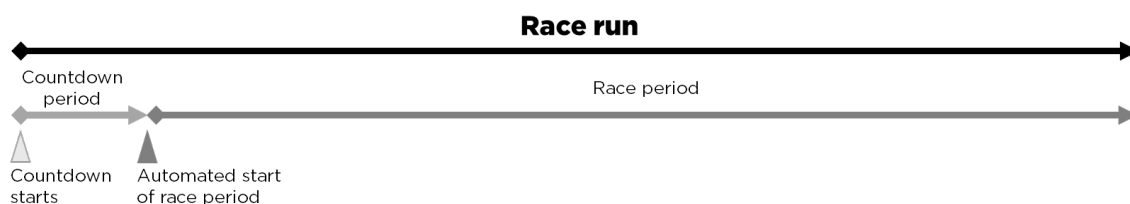
Comments

- If not defined otherwise, all dimensions are given in millimetres and weights in kilograms.
- Whenever possible, standard furniture and objects available at IKEA are used in the competition tasks.
- Furniture can be obtained from IKEA where available or built according to task drawings and (online) product specifications of the provider.
- See Appendix I for further details about the task infrastructure and objects.

3.4.1.2 Race procedures

GR-24 Each race run consists of a countdown period and race period.

GR-25 **The race period starts when the countdown ends. The task time of the first task starts with the end of the countdown.** If the pilot crosses the start line before the countdown has ended the start is not valid, and the pilot will be disqualified from the race run.



Overview of race procedures

3.4.1.3 Scoring

GR-26 Unless defined otherwise in the specific rules of a task, the pilot must cross each task obstacle once as they travel from the start to the finish line of the task.

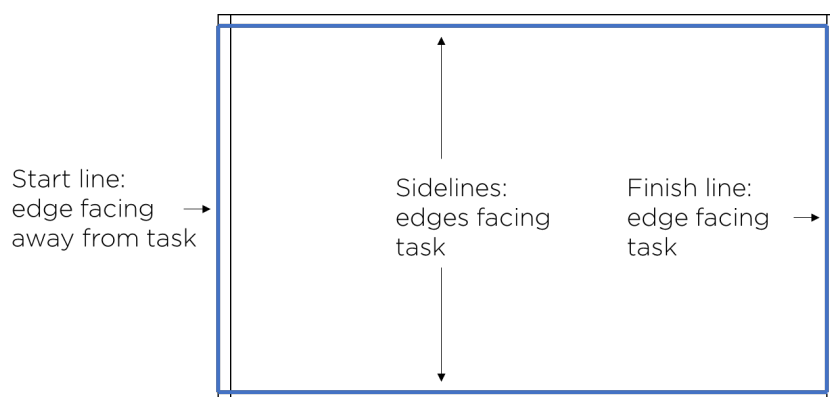
GR-27 The tasks must be solved in their order of appearance on the racetrack.

GR-28 It is not allowed to retry a task after having passed the finish line of the task, after skipping the task, or after the task is failed.

GR-29 If a task is skipped, the task must be passed on the far right-hand side (in race direction), if possible.

Comment on GR-29: In some tasks, the right-hand side is blocked by competition obstacles, hindering a proper re-entry on the track to reach the starting line of the next task. In these cases, it is allowed to pass more on the left-hand side.

GR-30 The reference edges of the start, finish, and sidelines are defined below and include its vertical projection:



Definition of reference edges of the task lines.

GR-31 The start and finish line of a task are considered to be crossed once the following part of the pilot or the assistive device crosses the reference edge (including its vertical projection):

- ARM: torso of the pilot
- LEG: torso of the pilot
- EXO: torso of the pilot

- WHL: any part of a wheel, track, or leg of the wheelchair
- VIS: torso of the pilot
- ROB:
 - any part of a wheel, track, or leg of the wheelchair
 - any wheel, track, or leg of the robot

GR-32 A task starts once the pilot crosses the reference edge of the task start line for the first time in a race run.

GR-33 Once a task has been started, the pilot is allowed to cross the reference edge of the start line again as long as the following part of the pilot or the assistive device does not cross the reference edge in its entirety:

- ARM: torso of the pilot
- LEG: torso of the pilot
- EXO: torso of the pilot
- WHL: any part of the wheel, track, or leg of the wheelchair closest to the finish line
- VIS: torso of the pilot
- ROB:
 - wheel, track, or leg of the wheelchair that is closest to the finish line
 - wheel, track, or leg of the robot that is closest to the finish line

Comment on GR-33: This can become relevant if additional space is required for manoeuvring between the start line and the first obstacle or object of a task.

GR-34 Unless defined otherwise in the discipline specific race rules, a task ends when the pilot crosses the reference edge of the task finish line for the first time.

GR-35 A race run is finished in any of the following instances:

- (1) The pilot crosses the finish line of the last task.
- (2) The time limit of the race period is reached.
- (3) The maximum number of warnings is reached.
- (4) A violation of a rule mandates termination of the race run.

The pilot's score at the moment the race run is finished is taken as the score for this race run.

- GR-36 If a pilot is issued three warnings within the same race run, the race run is terminated for that pilot. The pilot's current score is taken as the score for that race run. Each warning is communicated verbally to the pilot.
- GR-37 In case of race run termination, the pilot must proceed to the finish line of the task without any undue delay. If required, spotters may be asked to intervene and support the pilot to reach the finish line.
- GR-38 A task is failed if the reference edge of any sideline of the task space is crossed by any part of the assistive device (including crutches if applicable) or the pilot's body. Exceptions of this rule are assistive devices in the VIS race. Assistive devices in the VIS race (e.g., white canes), are allowed to cross the sideline of the task space.
- Comment 1 on GR-38: For a sideline to be considered crossed it is not a requirement that the ground beyond the reference edge of the sideline is touched by the pilot or the assistive device.
- Comment 2 on GR-38: If a task is completed and passed, it is allowed to cross the reference edge of the sidelines of this passed task (e.g., to skip the subsequent task). The completed task remains scored as passed.
- GR-39 A task is failed if any object of the task touches the ground beyond the reference edge of the sidelines or the start or finish line of the task space caused by any action of the pilot.
- GR-40 A task is failed if any task infrastructure is moved by the pilot or a spotter that is not explicitly asked to be moved by the task specific rules.
- GR-41 A task is failed if a pilot or a spotter touches a **red** object or liquid.
- GR-42 A task is failed if a pilot with any part of the body or device goes beyond a location that is **red** or that is coloured **red** in the task illustrations (including its vertical projection). In the Exoskeleton Race, the pilot's crutches are exempt from this rule.
- GR-43 A task is failed if any task object touches the ground, which, according to the task specific rules, does not have to touch the ground to solve the task.
- GR-44 A task is failed if a pilot uses the handrails. This includes the use of handrails to support movement or action or to keep balance by grasping, pulling, pushing or similar, with any part of the body or the assistive device. Handrails are provided for safety only.

GR-45 A task is failed if it is terminated prematurely by the pilot, by the referee due to an infringement, or by a physical intervention from a third person, i.e., a CYBATHLON official or a spotter.

GR-46 Task failure is indicated by a **red** flag and verbally communicated by the referee to the pilot (“task fail!”). Task passing is indicated by a green flag and verbally communicated by the referee to the pilot (“task pass!”).

GR-47 For each race run, the time to attempt each task is measured and points are scored if the task is solved successfully.

3.4.2 Mode & ranking

GR-48 Each pilot attempts two independent race runs.

GR-49 Each pilot is ranked relative to the performance of all other pilots of the same discipline, based on their score in their better race run. To rank the pilots, the following rules are applied:

- (1) sum of scored points
- (2) time needed to score the points
- (3) number of warnings received during the race run

GR-50 If two or more pilots achieve the same total score in the same total time and the same number of warnings in their better race run, they receive the same final rank.

Discipline	Race end	Ranking criteria	Final ranking
ARM			
LEG	1. Finish line of last task reached	1. Points scored	Pilots ranked relative to the performance of all other pilots in the same discipline, based on their highest total score in the better of their two attempts.
EXO	2. Time limit reached	2. Total time taken for scored points	
WHL	3. Three warnings received	3. Number of warnings	
VIS	4. A violation of a rule mandates termination of the race run		
ROB			

Summary of scoring and ranking criteria

GR-51 If a pilot does not agree with a referee’s decision during task execution, they must decide whether to continue or terminate the task. If the task is continued, the pilot must follow the procedures of an appeal against a

referee's decision during a race. If the pilot decides to terminate the task, no appeal can be filed.

3.4.3 Communication rules

The verbal communication during the races shall be held in the following form:

From the referee to the pilot in the following situations:

- Task fail, e.g., after the violation of a task rule: "task fail"
- Warnings: "warning number X"
- Race stop, e.g., after the issue of three warnings: "race stop"
- Confirmation of correct execution of predefined subtasks: "Ok go" or "Not yet" if referee does not agree with the current execution when the pilot asks for confirmation).

From the pilot to the referee in the following situations:

- Pilot is stuck in a task and requires help by the spotters to do so: "help"
- A pilot suspects a refereeing error and wants to submit an appeal after the race run: "continue task"
- Emergency: "S.O.S" (leads to the stop of the race)

3.4.4 Decision instances

GR-52 The CYBATHLON officials (i.e., timekeeper and referee) at the local hub act as the first decision instance, the CYBATHLON competition management acts as the second decision instance and may overrule the first decision instance.

GR-53 In case of any inconclusive occurrence or situation beyond a referee's decision, rules or regulations, the Head of Competition acts as the final decision instance.

3.4.5 Appeals

GR-54 In case of an occurrence or decision which is considered as unfair by one of the teams, they have the possibility to file a written appeal to the competition management. The regulations and procedures related to the appeals are defined in Appendix II.

3.5 Competition eligibility

3.5.1 Pilot eligibility criteria

Pilots must fulfil the following criteria to be eligible for participation:

GR-55 A pilot must pass the MedCheck.

GR-56 Pilots must be at least 18 years of age on the first day of the competition.

GR-57 Pilots must have sufficient cognitive and communicative abilities to understand the *Races & Rules* and to follow the instructions of the competition staff.

GR-58 Pilots must meet the discipline-specific pilot eligibility criteria.

Comment on GR-58: Pilots who have more severe disabilities than those defined in the eligibility criteria are eligible to participate, although they might have a disadvantage in comparison to those pilots who more closely match the eligibility criteria.

GR-59 Participation must be safe for the pilot at any time.

GR-60 If an assistive device (or (a) component(s) thereof) is implanted in the pilot's body (e.g., electrodes, sensors, osseointegration), the implants must be medically stable for at least six months and free of complications (e.g., infections) prior to and at the time of the competition.

GR-61 If the implanted assistive device or parts thereof are research prototypes, the team must have an approval of the responsible regulatory body governing the institution of the participating team. At the time of the competition the approval must be valid, and it must cover all applications and activities connected with participation in a CYBATHLON competition (e.g., travelling, application outside the lab).

GR-62 Medical information must be submitted by the teams several months prior to the competition in accordance with registration and submission deadlines. If a team does not meet the deadlines, they will be removed from the starting list.

GR-63 Once a pilot has passed the MedCheck, any change to the pilot's medical condition (affecting discipline eligibility or general health) must be communicated immediately to the CYBATHLON organising committee.

3.5.2 Technology eligibility criteria

It is allowed to use a commercial assistive device, a modified version of a commercial assistive device, prototypes, or research devices. In any case, assistive devices must fulfil all the following criteria to be eligible for participation:

- GR-64 The assistive device must pass the TecCheck.
- GR-65 The assistive device must be safe for the pilot and their environment at any time.
- GR-66 Technical, functional, and safety information about the assistive device must be submitted by the teams several months prior to the competition in accordance with registration and submission deadlines. If a team does not meet the deadlines, they will be removed from the starting list.
- GR-67 Assistive devices must meet the discipline-specific technology eligibility criteria to be allowed to participate in the competition.
- GR-68 After all requirements of the TecCheck have been met, no further changes may be made to the assistive device that would alter its function or its safety.
- GR-69 In addition to the predefined review during the TecCheck, additional reviews of a team's assistive device can be carried out by the technical examiners at any time during the competition. Teams who refuse the review will be disqualified.
- GR-70 Assistive devices (or (a) component(s) thereof) that are implanted in the pilot's body (e.g., electrodes, sensors, osseointegration) are eligible to participate (see also GR-60 and GR-61).
- GR-71 The pilot must be able to emergency stop the assistive device at any time during the competition

Comment on GR-71: In ROB, if the pilot is not able to emergency stop the device, the team must provide a concept on how to stop the device(s) in case of an emergency (e.g., a team official follows the robot on the track and activates the emergency stop if necessary.).

- GR-72 Combustion engines are not allowed.

4 Arm Prosthesis Race



ARM pilot solving the Breakfast task during CYBATHLON 2016.

4.1 Introduction

A limb difference at the level of the forearm or above (e.g., due to an amputation above the hand or a congenital disorder) may lead to significant challenges when interacting with the physical environment. While many of the latest anthropomorphic hand prostheses provide a wide variety of grip patterns, their use and range of functions is often not fully satisfying for their users. The devices still lack some of the fundamental functionalities of a human hand such as wrist flexion and extension or the control of individual fingers. Missing degrees of freedom often result in non-physiological compensatory movements. Most devices do also not provide proprioceptive and haptic sensory information to their user which can lead to a lack of embodiment and acceptance of the prosthesis. Furthermore, the control of a hand prosthesis often requires significant cognitive and visual attention from their users. Due to these functional shortcomings many arm prostheses users abandon their device in the long run.

Arm prostheses which fulfil the users' expectations and needs have the potential to prevent device rejection. Additionally, prostheses that enable the functions of a human hand in a natural way may prevent secondary negative long-term effects due to non-physiological movements or anatomical asymmetry.

4.2 Eligibility criteria

In addition to the General Rules outlined in Chapter 3, the following specific rules apply for the Arm Prosthesis Race:

4.2.1 Pilots

In addition to the general pilot eligibility criteria set forth in chapter 3.5.1 pilots must fulfil the following criteria to be eligible for participation in the ARM race:

- ARM-PIL-1 Pilots must have a transradial or more proximal amputation or dysmelia of at least one arm.

4.2.2 Technology

There are no specific eligibility criteria in addition to the general technology eligibility criteria set forth in Chapter 3.5.2.

General comments on the prostheses

- Unpowered or powered (motor or body powered) prostheses are allowed.
- The prosthetic device may have any number of actively driven (powered) joints (e.g., for hand opening/closing or wrist pronation/supination). The prosthetic device can have several passive or mechanically coupled joints (e.g., at the fingers). Body powered (e.g., cable driven) systems are also allowed.
- If not otherwise specified in the task specific rules, any technical modality (and their combination) to collect information about the environment is eligible (e.g., LIDAR, vision, ultrasound).
- There is no weight limit for the prosthesis.

4.3 Specific race rules

ARM-1 Pilots are not allowed to use items such as trailers, backpacks, bags, pockets, ropes, or their clothes to carry objects of the racetrack (e.g., tools, plates, and bags of the tasks), but it is allowed to use such aids to carry components of the device (e.g., batteries, control units, tools, replacement equipment, etc.).

ARM-2 It is not allowed to touch the prosthesis (except through its fixation to the stump or body), e.g., with the other hand or arm, while it is in direct contact with any competition infrastructure.

Comment on ARM-2: Non-robust control of prosthetic hand function during postural changes of the arm is an issue for many arm prostheses users. They oftentimes resort to turning off the device

to maintain a secure grip while carrying objects. While pragmatic and simple to implement, this approach is not satisfying to many users. Rule ARM-2 aims to encourage teams to seek novel solutions to device design and control to maintain robust function during postural changes of the arm.

- ARM-3 Unless defined otherwise in the specific rules of a task, any object on the racetrack that has **blue** parts is only allowed to be manipulated or touched with the prosthesis. **Only one blue object is allowed to be touched at a time.** If a pilot uses two prostheses, a **blue** object is only allowed to be manipulated or touched with one prosthesis at a time. **Blue** objects are only allowed to be manipulated or touched at the **blue** parts with the prosthetic hand (not including wrist, lower or upper arm).
- ARM-4 It is allowed to grasp objects of the racetrack that are not **blue** or do not have **blue** parts with the prosthetic hand to manipulate **blue** objects (e.g., to use it as a tool), but not with the non-prosthetic hand.

4.4 Task definitions

Each task is described in the following sections. If not otherwise defined, the direction of the race is (bottom) left to (top) right in all following figures.

4.4.1 Carry Bottles

4.4.1.1 Introduction

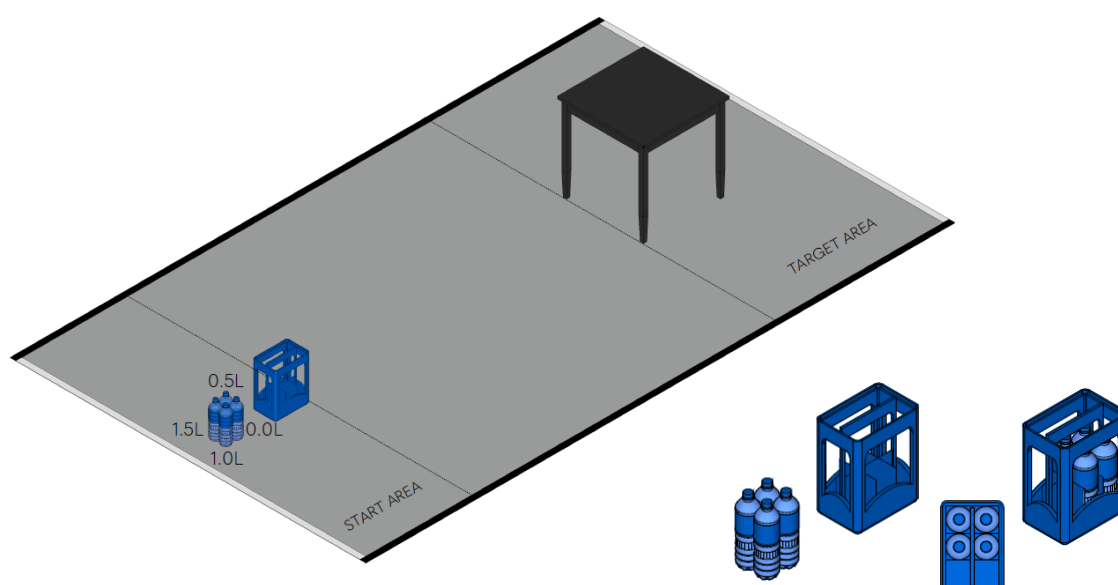
Forces that act on the prosthesis during the manipulation of heavy objects can cause a displacement of the prosthetic socket relative to the arm stump. In consequence the control signals recorded by traditional surface EMG can become unreliable leading to unsatisfactory function of the prosthesis.

In this task a series of bottles of different weights must be placed in a bottle crate and the crate must then be carried to a table. At the table, the bottles must be removed from the crate and placed on the table.



[Image source](#)

4.4.1.2 Task set-up & description



The pilot must carry the **blue** bottles using the **blue** bottle crate from the start area to the target area and then place the bottles on top of the table. The initial position

of the 1.5 l PET bottles with the different fillings (1.5 l, 1.0 l, 0.5 l, 0 l water) is defined as in the illustration. The order of placing the bottles in the crate is free.

4.4.1.3 Task rules

- ARM-BOT-1 The **blue** bottles must be carried to the table using the **blue** crate. The **blue** bottles must not be carried individually without the crate.
- ARM-BOT-2 The **blue** crate must not touch the ground between the start and the target area. The pilot is only allowed to lift up or set down the **blue** crate while both feet in their entirety are located in the start or target area.
- ARM-BOT-3 The **blue** crate is not allowed to be placed on top of the table.
- ARM-BOT-4 All **blue** bottles must be standing upright on the table at the time the pilot crosses the finish line of the task.
- ARM-BOT-5 If any of the **blue** bottles touches the ground again, after it has been lifted off the ground, the task is failed.

4.4.1.4 Comments

- Using other parts of the body (e.g., the legs or torso) to proactively to stabilize the crate or the bottles when carrying the crate is considered a task fail.

4.4.2 Clean Sweep

4.4.2.1 Introduction

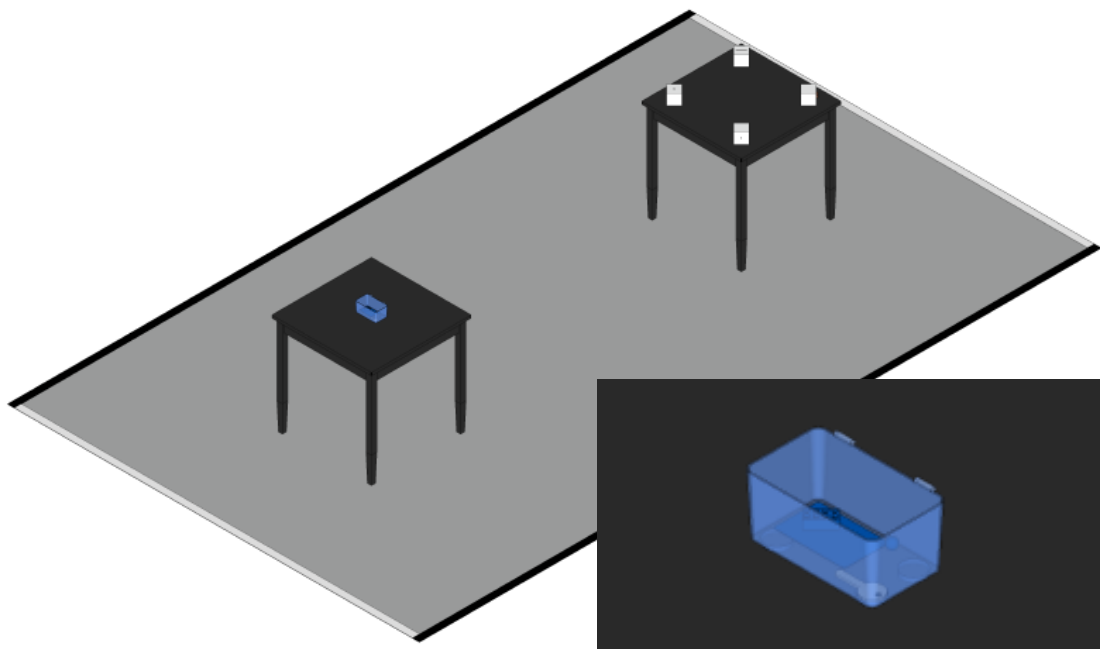
A vast variety of objects of different shape, size, compliance, texture, and weight must be grasped and manipulated in everyday life. The ability to cope with this diversity of requirements is challenged in this task.

In this task, pilots are asked to grasp and move **blue** objects individually with their prosthetic hand from their random, initial position on a table surface to a target position on a neighbouring table.

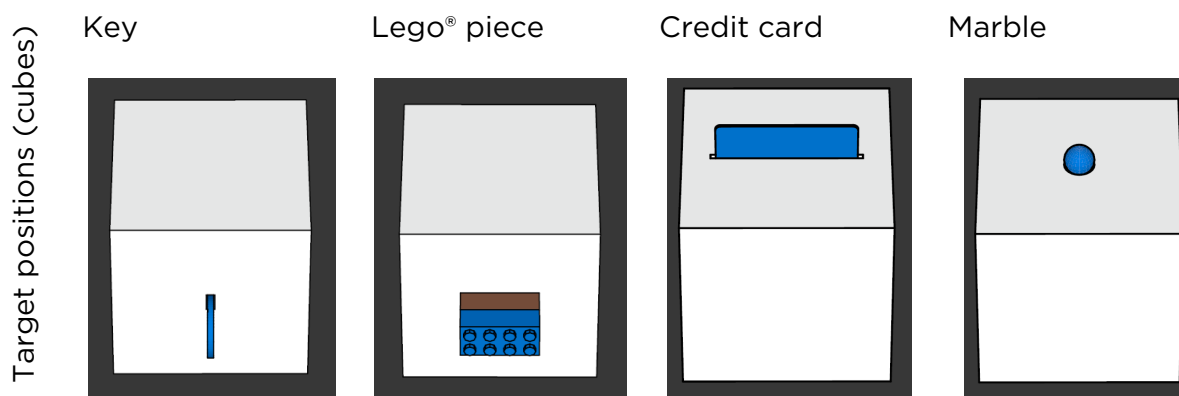


[Image source](#)

4.4.2.2 Task set-up & description



The **blue** objects that are initially located in the **blue** box on the table near the start line must be carried to and placed at their respective target position on the table near the finish line.



4.4.2.3 Task rules

ARM-CLEAN-1 All **blue** objects must be moved from their random initial position in the **blue** box on the table near the start line to their designated target position on the table near the finish line. The order in which the objects are carried to and placed at their target position is not defined.

Comment on ARM-CLEAN-1: **The long side of the box is parallel to the start line. The long side of the box with the hinges is closest to the finish line.** It is allowed to stabilize the target position on the table using the non-prosthetic hand, but it is not allowed to intentionally move or lift the target position off the table surface.

Comment on ARM-CLEAN-1: The target positions (cubes) are fixed on the table (e.g., with tape or screws).

ARM-CLEAN-2 It is not allowed to transport the blue objects using the blue box. While the pilot is placing blue objects to their designated target position, the blue box must remain on the table near the start line.

ARM-CLEAN-3 All **blue** objects must be located at their designated target position on the table near the finish line when passing the finish line of the task. Otherwise, the task is failed.

4.4.2.4 Comment

- According to rule ARM-3 it is not allowed to grasp the **blue** box on the table near the start line using the non-prosthetic hand.

4.5 Competition mode and scoring

- Points per task: 10
- Total race duration: 4 min

5 Leg Prosthesis Race



LEG pilot solving the Tilted Path task during CYBATHLON 2020 Global Edition.

5.1 Introduction

A transfemoral limb difference above the knee (e.g., due to an amputation or a congenital disorder) may lead to significant challenges in personal mobility. Current micro-processor controlled transfemoral leg prostheses can control the mechanical properties of their joints (e.g., the stiffness of the knee) depending on the phase of the user's gait cycle and adapt to different gait types. Nonetheless, the functionality of current devices does not always optimally support their users. Many prostheses are not actuated, i.e., they do not have a motor as part of the knee joint. As a result, they cannot adequately support a user when getting up from a chair, climbing stairs or walking uphill. This leads to asymmetric gait and increased energy expenditure by the user. The lack of actuation also means that the user cannot voluntarily control the angle of the knee (i.e., actively extend or bend the knee as needed). This function is for example required when getting into a car) or sitting down on a crowded bench (e.g., not hitting the people sitting already on the bench). The lack of actuation generally leads to compensatory movements which can have negative long-term effects on the user's health such as musculoskeletal symptoms in the back or in the healthy leg. Furthermore, current devices lack the provision of proprioceptive and haptic sensory

feedback from the joints or the sole of the user's foot. Consequently, their use can be strenuous, is not very intuitive, and requires a lot of attention and training from the user.

Leg prostheses which mimic and enable the natural function of the human legs bear the potential to optimally support their users. Leg prostheses that can be controlled intuitively and allow for symmetric gait lead to better device acceptance by increasing the satisfaction of their users.

5.2 Eligibility criteria

In addition to the General Rules outlined in chapter 3, the following specific rules apply for the Leg Prosthesis Race:

5.2.1 Pilots

In addition to the general pilot eligibility criteria set forth in chapter 3.5.1 pilots must fulfil the following criteria to be eligible for participation in the LEG race:

- LEG-PIL-1 Pilots must have a knee exarticulation or more proximal amputation of at least one leg.

5.2.2 Technology

There are no specific eligibility criteria in addition to the general rules set forth in chapter 3.5.2.

General comments on the prostheses

- Any kind of unpowered or powered prosthesis is allowed.
- The prosthesis can have any number of actively driven (i.e., powered) joints. The residual body parts can also be instrumented and electronically and/or mechanically connected to the prosthesis.
- Any technical modality (and their combination) to collect information about the environment is eligible (e.g., LIDAR, vision, ultrasound).
- There is no weight limit for the prosthesis.

5.3 Specific race rules

LEG-1 The use of any type of walking aid (e.g., crutches, canes, or similar) during the competition is not allowed.

LEG-2 Pilots are not allowed to use items such as trailers, backpacks, bags, pockets, ropes or their clothes to carry objects of the racetrack (e.g., tools, plates, and bags of the tasks), but it is allowed to use such aids to carry components of the device (e.g., batteries, control units, tools, replacement equipment).

LEG-3 Any object on the racetrack that is **red** is not allowed to be touched with any part of the assistive device or any other body part.

LEG-4 Any part of a task that is **blue** must be touched with the prosthetic leg (including the shoe) during task execution. Any part of a task that is **blue** must only be touched with the prosthesis during task execution.

LEG-5 It is not allowed to manipulate the prosthesis with the hands, arms, or any other body part **to support** movement of the prosthesis.

Comment on LEG-5: It is allowed to, e.g., use a switch or press a button on the prosthesis to change the modality or function of the prosthesis.

5.4 Task definitions

Each task is described in the following sections. If not otherwise defined, the direction of the race is (bottom) left to (top) right in the following figures.

5.4.1 Hurdles

5.4.1.1 Introduction

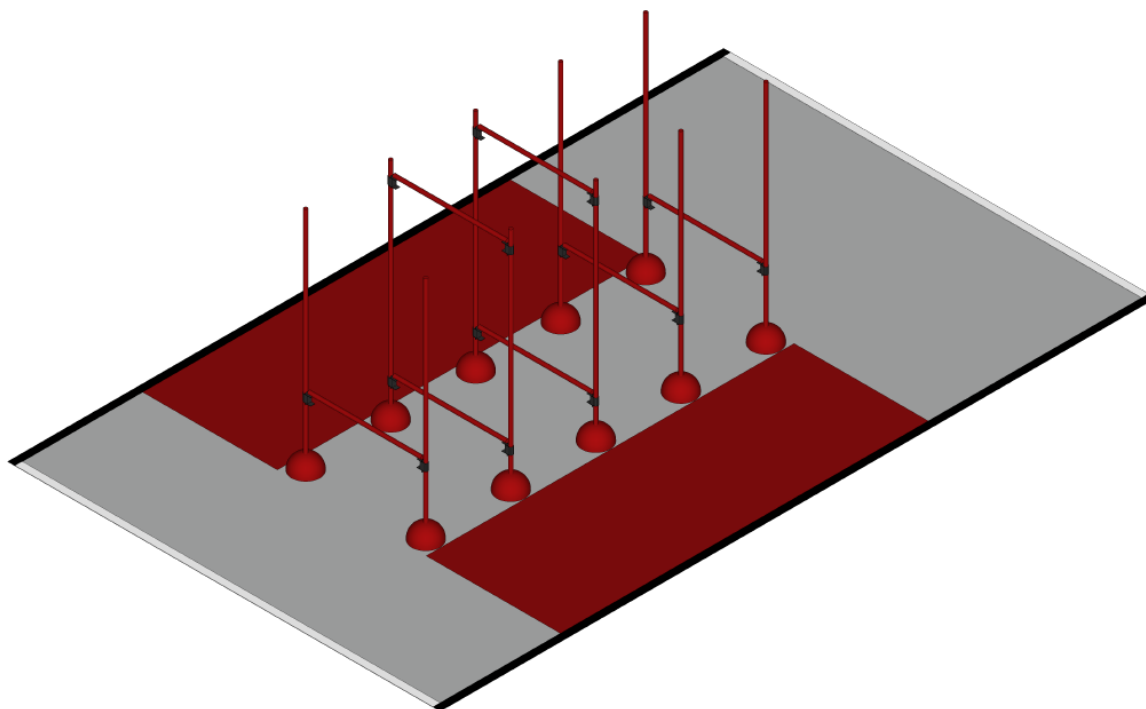
Sometimes, it is necessary to step over objects that are even higher than standard steps or to crouch to pass beneath objects, e.g., when walking in a forest, crossing a fence, or on a construction site.

In this task, the pilots have to pass a series of hurdles.



[Image source](#)

5.4.1.2 Task set-up & description



The pilots must pass once between each pair of poles without knocking down any of the poles or crossbars. When passing between the poles, the leading leg must alternate.

5.4.1.3 Task rules

- LEG-HURD-1 The vertical poles that are connected by at least one crossbar are considered a pair. Pilots must pass once between each pair of poles.
- LEG-HURD-2 When passing between the pairs, the leading leg must alternate. I.e., if for the first pair, the left leg is leading, for the second pair, the right leg must be leading and so on.
- LEG-HURD-3 If the pilot knocks down a crossbar, either by hitting a pole or a crossbar, the task is failed.
- LEG-HURD-4 Pilots are not allowed to grasp any crossbar or pole with the hand or steady it with any other part of the body.

5.4.2 Ladder

5.4.2.1 Introduction

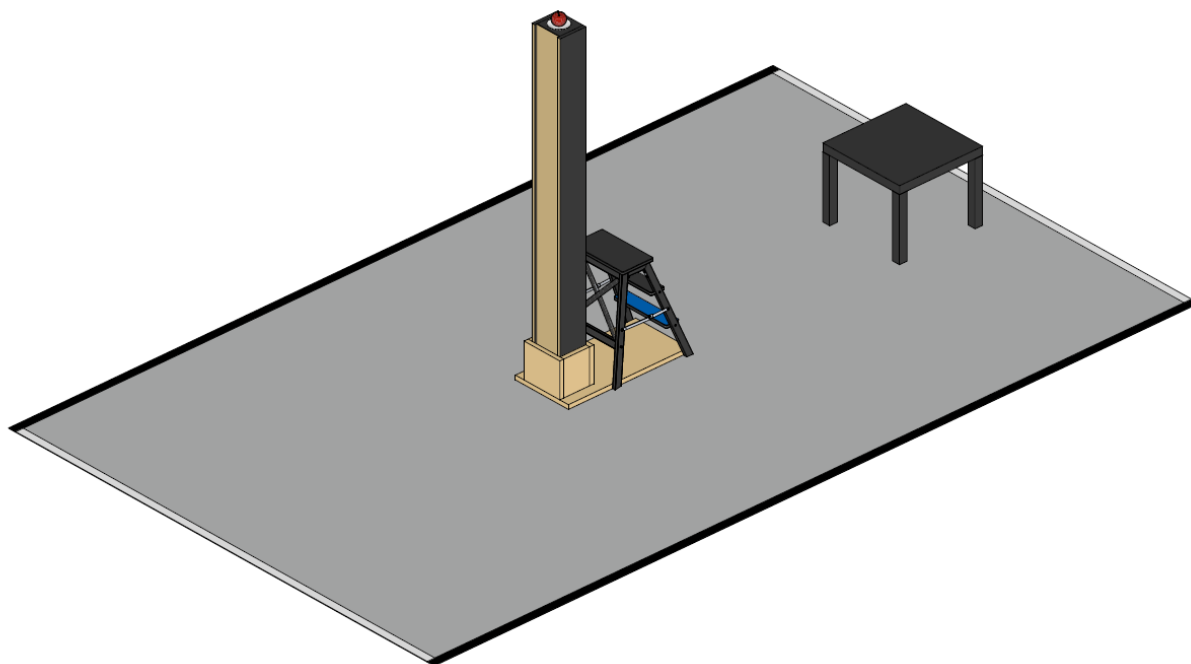
Climbing and descending ladders with a transfemoral leg prosthesis is arduous and requires a lot of attention from the user.

In this task, pilots must climb up and down a stepladder by placing their feet only in predefined locations while balancing an apple on a plate.



[Image source](#)

5.4.2.2 Task set-up & description



The pilot must climb up the stepladder to pick up a plate with a **red** apple from the top of the shelf. The pilot then carries the plate and apple while climbing down from the stepladder and places it on the table.

5.4.2.3 Task rules

LEG-LADDER-1 Each step must be stepped on when climbing and descending the stepladder.

Comment on LEG-LADDER-1: Pilots are not allowed to omit single steps or jump over steps of the stepladder.

LEG-LADDER-2 Steps 1 (**blue**) and 2 must each be stepped on by one foot only. The leading leg must alternate.

LEG-LADDER-3 Picking-up the plate is only allowed when standing on step 3 (top) with both legs.

LEG-LADDER-4 When crossing the finish line of the task, the **red** apple must be on the plate, the plate must be located on the table

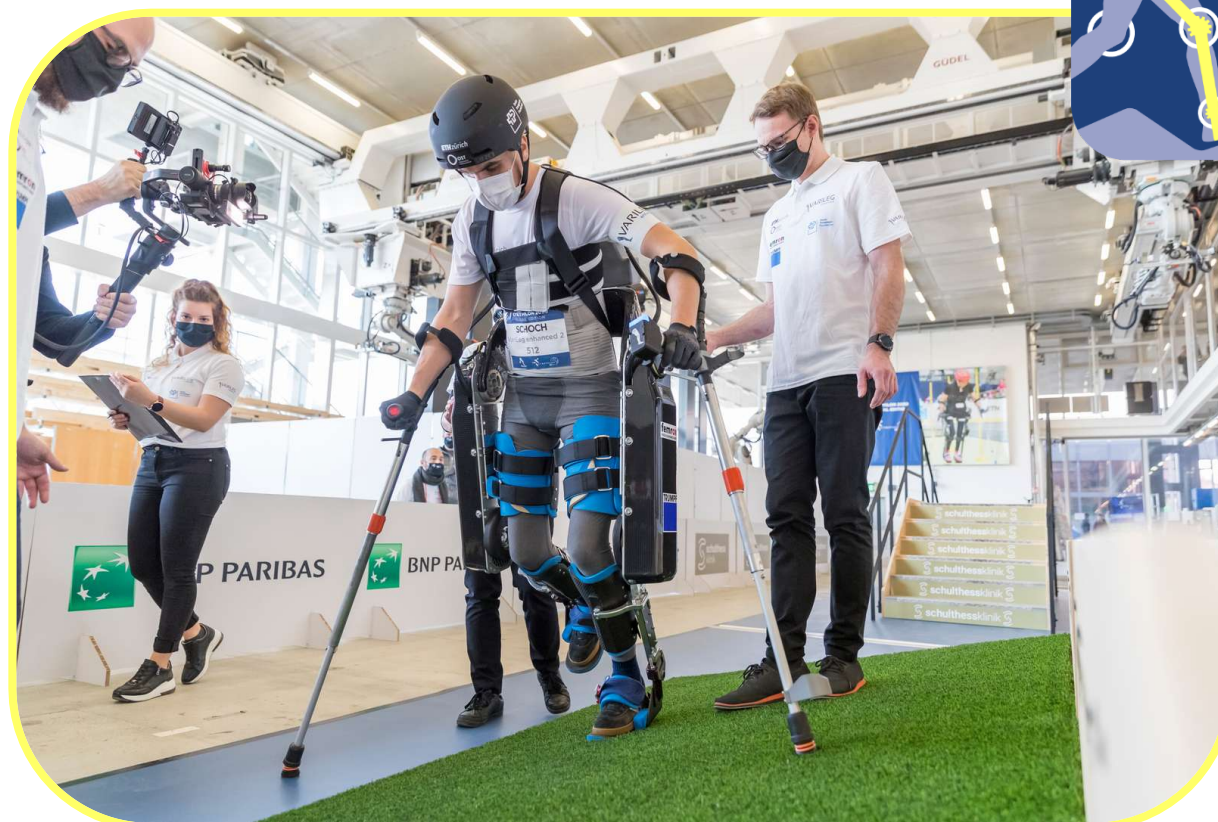
LEG-LADDER-5 It is only allowed to grasp the plate, but not the **red** apple. It is only allowed to transport the **red** apple by balancing them on the plate.

LEG-LADDER-6 If the **red** apple drops, the task is failed.

5.5 Competition mode and scoring

- Points per task: 10
- Total race duration: 3 min

6 Exoskeleton Race



EXO pilot solving the Tilted Path task during CYBATHLON 2020 Global Edition.

6.1 Introduction

Robotic exoskeletons are devices that enable paraplegic individuals to stand upright, walk, or to climb and descend stairs. Even though robotic exoskeletons for paraplegics have been in development since the late 1960's and early 1970's, the technology has not matured to a point where the devices are accepted by the end-users. The usability of current exoskeletons is attenuated by shortcomings such as a limited situational adaptability of their movement patterns (usually based on predefined motion profiles), the need for crutches, and time-consuming donning and doffing. Furthermore, the physical and cognitive load to the pilot combined with the need for crutches impedes the user from performing secondary tasks while walking. Therefore, current devices do not offer an actual alternative to the wheelchair yet. However, the prolonged use of a wheelchair can also be accompanied with challenges to the user's general health such as musculoskeletal symptoms in the arms and shoulders due to overuse, impaired blood circulation, or osteoporosis in the lower limbs due to the lack of loading in the seated position.

Robotic exoskeletons enabling an upright posture and gait for paraplegic users bear the potential to address many of the above-mentioned shortcomings associated with

prolonged wheelchair use. The ability to communicate with peers on eye-level while standing is an often mentioned and welcome additional feature of exoskeleton use indicating that there is also a positive social impact of this technology.

6.2 Eligibility criteria

In addition to the General Rules outlined in chapter 3, the following specific rules apply for the EXO Race:

6.2.1 Pilots

In addition to the general pilot eligibility criteria set forth in chapter 3.5.1 pilots must fulfil the following criteria to be eligible for participation in the EXO race:

- EXO-PIL-1 Pilots must have a spinal cord injury with paraplegia and a complete loss of motor function in the lower limbs (AIS A or B, <http://www.sci-info-pages.com/levels.html>).
- EXO-PIL-2 Pilots must have sufficient voluntary control and strength of the upper body to control the exoskeleton.

General comments

- The eligibility of pilots with lesions affecting the control of trunk, arm and/or neck is evaluated on a case-by-case basis.
- Pilots can have a spastic or non-spastic lesion.

6.2.2 Technology

The assistive device must fulfil the following criteria to be eligible for participation in the EXO race:

In addition to the general technology eligibility criteria set forth in Chapter 3.5.2, the assistive device must fulfil the following criteria to be eligible for participation in the EXO race:

- EXO-TEC-1 Crutches or canes are allowed.
- EXO-TEC-2 Load transfer to the ground via wheels or rolling contact is not allowed.

General comments

- Any kind of input device or automated gait intention detection strategy is allowed.
- Any type of joint actuation is allowed. Also, passive joints are allowed.
- Any technical modality (and their combination) to collect information about the environment is eligible (e.g., LIDAR, vision, ultrasound).
- Functional electrical stimulation can be added to assistive device.

6.3 Specific race rules

- EXO-1 Wearing a helmet is mandatory. The teams are required to bring their own helmet.
- EXO-2 If crutches or canes are used, they must be carried by the pilot during the entire race.
- EXO-3 Pilots must walk such that during any point in time, at least one of their feet is in contact with the ground, i.e., swing-through gait patterns are not allowed.

6.4 Task definitions

Each task is described in the following sections. If not otherwise defined, the direction of the race is (bottom) left to (top) right in all the following figures.

6.4.1 Boxes

6.4.1.1 Introduction

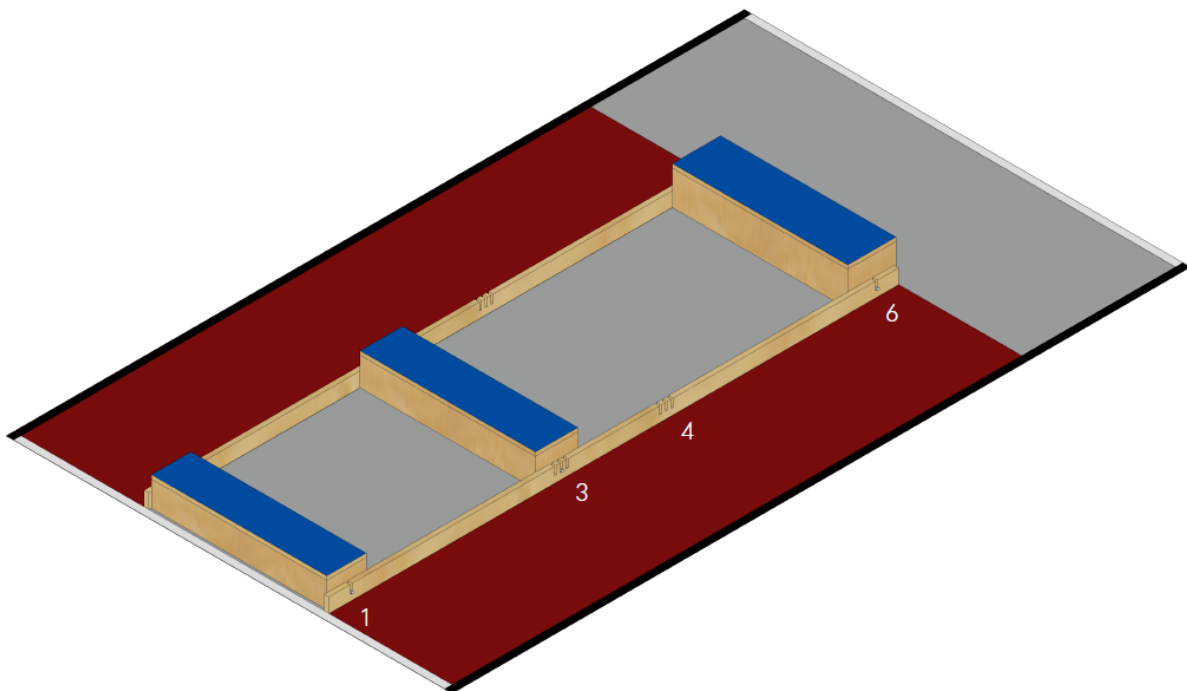
Walking on surfaces that require irregular step lengths and heights is challenging since the position of the foot must be continuously controlled.

In this task, pilots must negotiate a quasi-random sequence of wooden boxes that vary in height and length.



[Image source](#)

6.4.1.2 Task set-up & description



The pilots must step on a sequence of three boxes. Pilots must step on each box with at least one foot.

The sequence of the boxes is randomized according to the following set of rules:

- The boxes will be installed in the following positions: 1, 3 or 4, 6 (see above).
- Three types of boxes will be presented (see Appendix I of the CYBATHLON 2024 Races & Rules for further details about the boxes).

6.4.1.3 Task rules

- EXO-BOX-1 Pilots must cross the sequence of boxes once in the direction of the race.
- EXO-BOX-2 Pilots must step on each box with at least one foot.
- EXO-BOX-3 Pilots are not allowed to place one foot on one side of the box while having the other foot on the other side of the box at the same time.

Comment on EXO-BOX-3: The idea is to hinder pilots to just tip the surface of the box with their foot and then step over the box.

6.4.2 Kitchen

6.4.2.1 Introduction

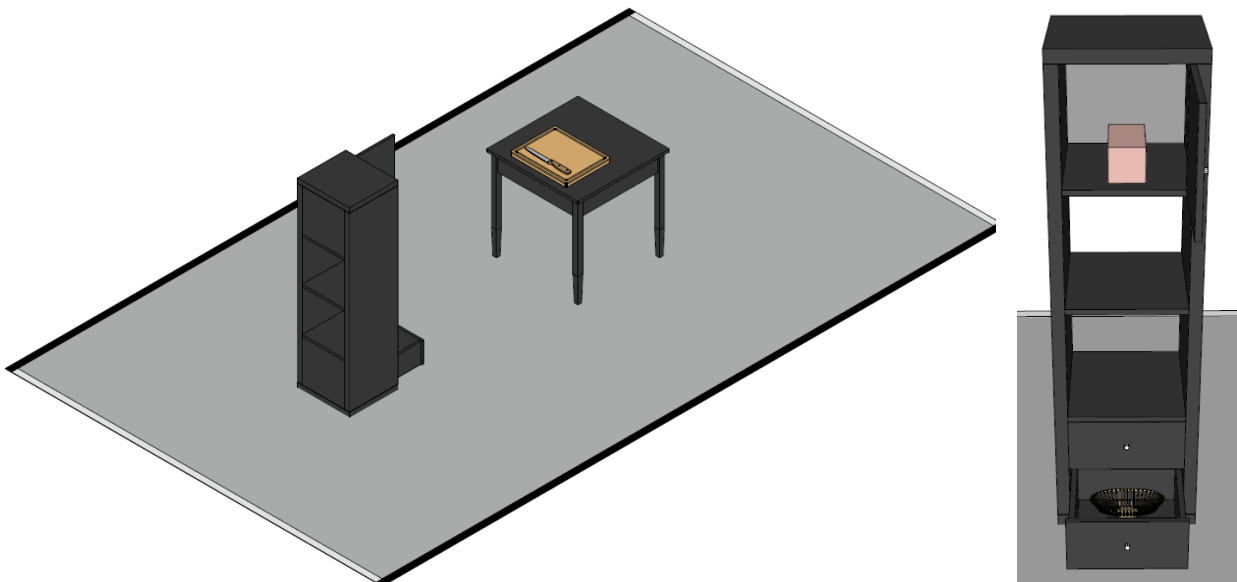
For exoskeletons to be practical for everyday use, they must allow their user to perform auxiliary tasks that go beyond the basic walking functions. Such auxiliary tasks are then usually performed with the upper extremities and can involve manipulation of objects at various levels above the ground.

In this task, pilots must conduct several upper extremity tasks while standing in a kitchen environment in their exoskeleton.



[Image source](#)

6.4.2.2 Task set-up & description



The bread and the basket must be taken from the cupboard and carried to the table. On the table, a slice of 'bread' must be cut off and placed in the basket. The shelf and drawer will be initially closed, they are shown open above for clarity only. Since the

basket is not fixed in the drawer, it can potentially move in the drawer when it is opened.

6.4.2.3 Task rules

- | | |
|---------------|---|
| EXO-KITCHEN-1 | A cuboid slice of uniform thickness of approximately 20 mm width must be cut off the foam on the breadboard, using the breadknife. The slice must be clearly separated from the rest of the foam by cutting and then placed in the breadbasket. |
| EXO-KITCHEN-2 | The breadbasket (containing the cut slice of foam), the knife, the foam, and the breadboard must be located on the table (no specific target location) when the pilot crosses the finish line of the task. |
| EXO-KITCHEN-3 | The door of the cupboard and the drawers must be closed when the pilot crosses the finish line of the task. |

6.5 Competition mode and scoring

- Points per task: 10
- Total race duration: 4 min

7 Wheelchair Race



WHL pilot solving the Stairs task during CYBATHLON 2020 Global Edition

7.1 Introduction

People with a severe walking disability who use a powered wheelchair for personal mobility are often confronted with challenges when interacting with their physical environment. Single steps (e.g., a curb), flights of stairs, or uneven terrain can pose significant obstacles. Depending on a user's function of the trunk and arms it can also be very arduous to open/close a door or to pick up an object from the ground. Users often must rely on the help of a third person to overcome such situations.

Recently, technologies such as stair climbing mechanisms or robotic manipulators have been developed to provide support in some of the abovementioned situations. However, these technologies are often developed for specific tasks only and thus they do not perform well in varying scenarios. Their use is not versatile, often not intuitive, and therefore unsatisfying and frustrating for the user.

The addition of technologies to powered wheelchairs, such as stair climbing mechanisms or robotic manipulators, bear the potential to improve the autonomy in personal mobility of people with a severe walking disability in daily life.

7.2 Eligibility criteria

In addition to the General Rules outlined in chapter 3, the following specific rules apply for the Wheelchair Race:

7.2.1 Pilots

In addition to the general pilot eligibility criteria set forth in chapter 3.5.1 pilots must fulfil the following criteria to be eligible for participation in the WHL race:

- WHL-PIL-1 Pilots must have a severe walking disability due to any kind of central nervous system disease or injury, any systemic neural or muscular disease or bilateral above knee amputation.
- WHL-PIL-2 Pilots must be able to control their wheelchair. Thus, the pilots must have sufficient voluntary control of head, shoulder, hand, finger, tongue and/or voice to operate an input device.

7.2.2 Technology

In addition to the general technology eligibility criteria set forth in Chapter 3.5.2 the assistive device must fulfil the following criteria to be eligible for participation in the WHL race:

- WHL-TEC-1 Both powered wheelchairs and manual wheelchairs that are powered by an external device are allowed, provided the power is solely produced by the device and not by the pilot.

Comment on WHL-TEC-1: Concepts like e-motion wheelchairs are not allowed since it is not possible to distinguish if the energy comes from the user or the device.

- WHL-TEC-2 Chest, shoulder, leg, foot, and head restraints or any other type of restraint are allowed provided they are required to secure the pilot in the device.

- WHL-TEC-3 Backpacks, bags, or similar can be attached to the powered wheelchairs during the race provided they do not pose a hazard to the pilot and the environment.

General comments

- Input (control) devices can include any standard or novel technology such as a hand joystick, head joystick, a sip & puff controller, a tongue drive, headrest switches, a touchpad, a tiller, a BCI, speech processing methods or any other technology.
- Load transfer to the ground can occur using wheels, tracks, or other means. Legged or wheeled-legged robots are also allowed.

- Any technical modality (and their combination) to collect information about the environment is eligible (e.g., LIDAR, vision, ultrasound).
- Any type of active actuation (other than combustion) is allowed.
- It is recommended that the width of the wheelchair does not exceed 900 mm (otherwise, it cannot pass many of the obstacles).

7.3 Specific race rules

WHL-1 Wearing a helmet is mandatory. The teams are required to bring their own helmet.

WHL-2 If any handrails are used to support movement or action or used to keep balance by grasping, pulling, pushing or similar, with any part of the body, the task is failed. Handrails are provided for safety reasons only.

WHL-3 Any object coloured **blue** in any of the following drawings must only be touched and manipulated using the robotic manipulator.

Comment on WHL-3: In case the robotic manipulator is not a robotic arm mounted to the wheelchair in the Wheelchair Race, the eligibility of the manipulator is evaluated in the TecCheck.

Comment on WHL-3: Pilot and the manipulator must be located in the same task space at a given time. For example, the pilot, located on task 1, cannot send the manipulator ahead to start completing task 2.

WHL-4 Pilots are only allowed to operate the robotic manipulator while they are attempting the respective task. During completion of all other tasks, the robotic manipulator must be in a safe state such that it cannot present an impending hazard to the pilot or to bystanders.

Comment on WHL-4: The safe state for a given robotic manipulator is subject to agreement between the head of discipline and the team.

WHL-5 The end effector of the robotic manipulator may be exchanged during the race. The process must be fully externally powered and not require any manipulation by the pilot other than operating the input device.

Comment on WHL-5: Pilots with good motor function of their upper extremities (e.g., low lesion level) would have an advantage over pilots with more severely impaired motor function of their upper extremities (e.g., high lesion level) if manual exchange of the end effector was allowed.

WHL-6 The energy required for actuating the robotic manipulator (e.g., positioning, actuate door handle, open/close door in the **Door** task) must not be provided by the pilot.

7.4 Task definitions

Each task is described in the following sections. If not otherwise defined, the direction of the race is (bottom) left to (top) right in all the following figures.

7.4.1 Doorstep

7.4.1.1 Introduction

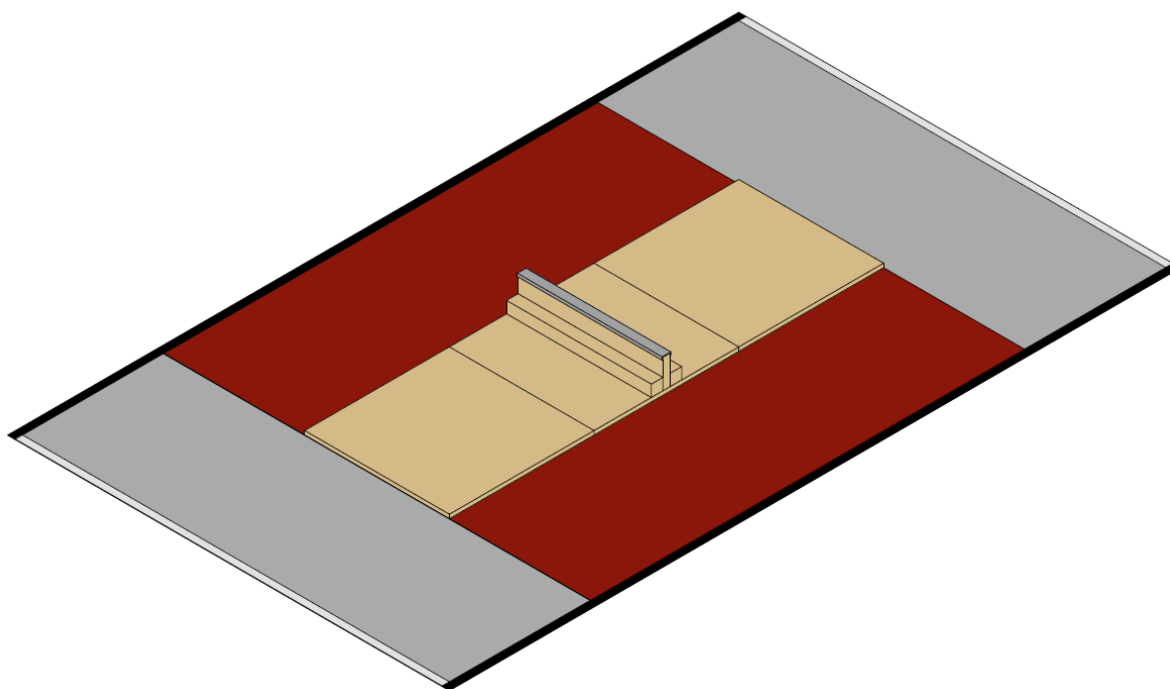
Crossing the doorstep is usually the first step when entering a building. They come in many different sizes, and it is often decided at the doorstep if a wheelchair user can enter or leave a building at all. Powered wheelchairs should therefore be able to negotiate a big variety of doorsteps.

In this task, pilots and their devices are challenged to negotiate different types of doorsteps.



[Image source](#)

7.4.1.2 Task set-up



The obstacle must be crossed once in the direction of the race.

7.4.1.3 Task rules

WHL-STEP-1 The obstacle must be crossed once in the direction of the race.

7.4.2 Crowd

7.4.2.1 Introduction

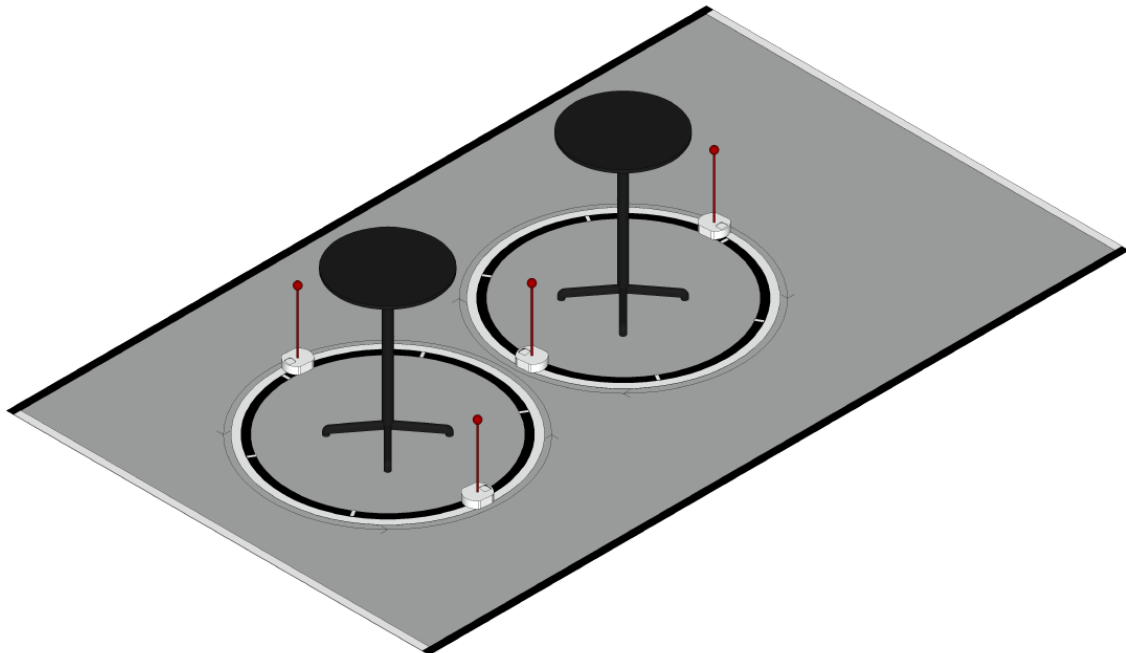
Often in daily life, it is necessary to navigate around static or moving obstacles to reach a desired destination. When moving in dynamic crowds in particular, a constant control of direction and speed is required to avoid collisions.



[Images source](#)

In this task, pilots must pass between individual pieces of furniture. In addition, collisions with several robots that are roaming the task space must be avoided.

7.4.2.2 Task set-up & description



The pilot must pass between the tables without touching the orbiting robots.

- The starting position of the robots is as indicated in the picture.
- The robots are set in motion when the races starts.
- The first two orbits for one robot take appr. 36 s. Thereafter, the orbit duration increases 0.12 s per s **whereas an update of the speed only occurs whenever the robot passes one of the six marks**. When the orbit duration has reached 72 s, the orbit duration will be kept constant.
- The robots orbit counter-clockwise around the first table and clockwise around the second table.
- The two robots that orbit around a given table always have a phase shift of 180°.
- The robots that orbit around the first table have a phase shift of 90° as compared to the robots that orbit around the second table. The exact starting positions will be communicated at a later stage.

7.4.2.3 Task rules

WHL-CROWD-1 The pilots must pass once between the two tables.

WHL-CROWD-2 The task is failed in case of any contact between wheelchair, or any of the pilot's body parts with any of the robots.

7.4.2.4 Comments

- The first piece of furniture can be passed on the left- or on the right-hand side.
- If an orbiting robot leaves its track or stop, a CYBATHLON official will remove the robot. The pilot can continue the task with less orbiting robots.

7.5 Competition mode and scoring

- Points per task: 10
- Total race duration: 3 min

8 Assistance Robot Race



A wheelchair user is being handed a bottle by a personal assistance robot ([Image source](#))

8.1 Introduction

People with severe motor impairments or missing limbs to both the upper and the lower extremities have limited autonomy when interacting with their physical environment resulting from their disability. Tasks such as shopping for groceries independently, eating and drinking, personal hygiene, or dishwashing are just a few examples in which these people might depend on a care person.

Assistance robots are a relatively new category of assistive devices which can accompany a user with limited motor control in daily life. They can assist and take over some of the tasks which are otherwise managed by a care person. To become a fully accepted technology these devices must be seamlessly integrated and capable to meaningfully contribute to the manifold domains of daily life. Their use must be effortless and reliable while providing diverse functions such as the dexterous manipulation of delicate objects or the autonomous avoidance of obstacles.

Assistance robots bear potential to increase the autonomy of people who have very little to no voluntary motor control of their limbs due to their disability.

8.2 Eligibility criteria

In addition to the General Rules outlined in chapter 3, the following specific rules apply for the Assistance Robot Race:

8.2.1 Pilots

Pilots must fulfil the following criteria to be eligible for participation in the ROB race:

ROB-PIL-1 Pilots must be wheelchair users in daily life and have a severe impairment of both upper limbs due to pathologies such as any kind of central nervous system disease or injury, any systemic neural or muscular disease, a bilateral shoulder disarticulation, or phocomelia.

Comment on ROB-PIL-1: In case of doubt whether a pilot candidate meets this feasibility criterion, please get in touch with the CYBATHLON organizing committee.

ROB-PIL-2 Pilots must have sufficient ability to control their wheelchair as well as their personal assistance robot at any time.

8.2.2 Technology

The envisioned technology approach is a robotic manipulator mounted to a mobile platform. The mobile platform can be the pilot's own wheelchair or an auxiliary device. Exemplary approaches are given in the table below. In the first envisioned approach, the combination of the robotic manipulator and the pilot's wheelchair is considered the personal assistance robot. In the second envisioned approach, the robotic manipulator and its mobile base are considered the personal assistance robot.

Exemplary approaches



Envisioned approach 1: A robotic manipulator mounted to a powered wheelchair.



Envisioned approach 2: A person in a powered wheelchair and a robotic manipulator mounted to an auxiliary mobile platform. [Image source](#)

The assistive device must fulfil the following criteria to be eligible for participation in the ROB race:

- ROB-TEC-1 The mobile base and the wheelchair used by the pilot must fulfil the technology eligibility criteria for the WHL race (see chapter 7, page 44).
- ROB-TEC-2 Only actively driven robotic manipulators are eligible.

General comments

- The personal assistance robot should be designed in compliance with ISO 13482:2014 (or similar regulations applied in the country of development).
- Input (control) devices can include any standard or novel technology such as a hand joystick, head joystick, a sip & puff controller, a tongue drive, headrest switches, a touchpad, a tiller, a BCI, speech processing methods or any other technology.
- Any type of actuation is allowed.
- Any technical modality (and their combination) to collect information about the environment is eligible (e.g., LIDAR, vision, ultrasound).
- Multiple robotic manipulators mounted to the same mobile platform can be used.
- Load transfer to the ground can occur using wheels, tracks, or other means. Legged or wheeled-legged robots are also allowed.

8.3 Specific race rules

ROB-1 The end effector of the robotic manipulator may be exchanged during the race. The process must be fully externally powered and not require any manipulation by the pilot other than operating the input device.

ROB-2 The energy required to manipulate the task objects must come entirely from the robot and not from the pilot.

Comment on ROB-2: The operation of the robot by the pilot is excluded from this rule.

ROB-3 Pilots are not allowed to actively touch or carry any objects of the tasks (e.g., grasping, holding in the hands or between the teeth, pinching between shoulder and head or in the arm pit). If any objects must be transported as part of a task, the object must be carried by the assistance robot.

Comment on ROB-3: This rule intends to reduce the impact of the pilot's residual motor function on task difficulty. The assistance robot may however place an object on the pilot's lap.

ROB-4 Any object coloured blue in any of the following drawings must only be touched and manipulated using the robotic manipulator.

In case a pilot uses an auxiliary mobile platform as the assistance robot the following additional rules apply:

ROB-4 Two referees judge the race. One referee observes the pilot, and one referee observes the assistance robot.

ROB-5 Task timing is based on the location of the pilot. The task time is started and stopped when the pilot crosses the start-/ finish line.

ROB-6 Task completion is based on the location of pilot and assistance robot. A task is considered completed when the task is solved, and both (pilot and assistance robot) **crossed the finish line have left the task space. Once the pilot or the assistance robot have crossed the finish line of the task, neither the pilot is allowed to go back nor the assistance robot is allowed to go back to this task.**

Comment on ROB-6: This means that the pilot and the assistance robot do not have to be located on the same task at a given time. For example, the pilot, located on task 1, can send the assistance robot ahead to start completing task 2.

8.4 Task definitions

Each task is described in the following sections. If not otherwise defined, the direction of the race is (bottom) left to (top) right in all the following figures.

8.4.1 Eating

8.4.1.1 Introduction

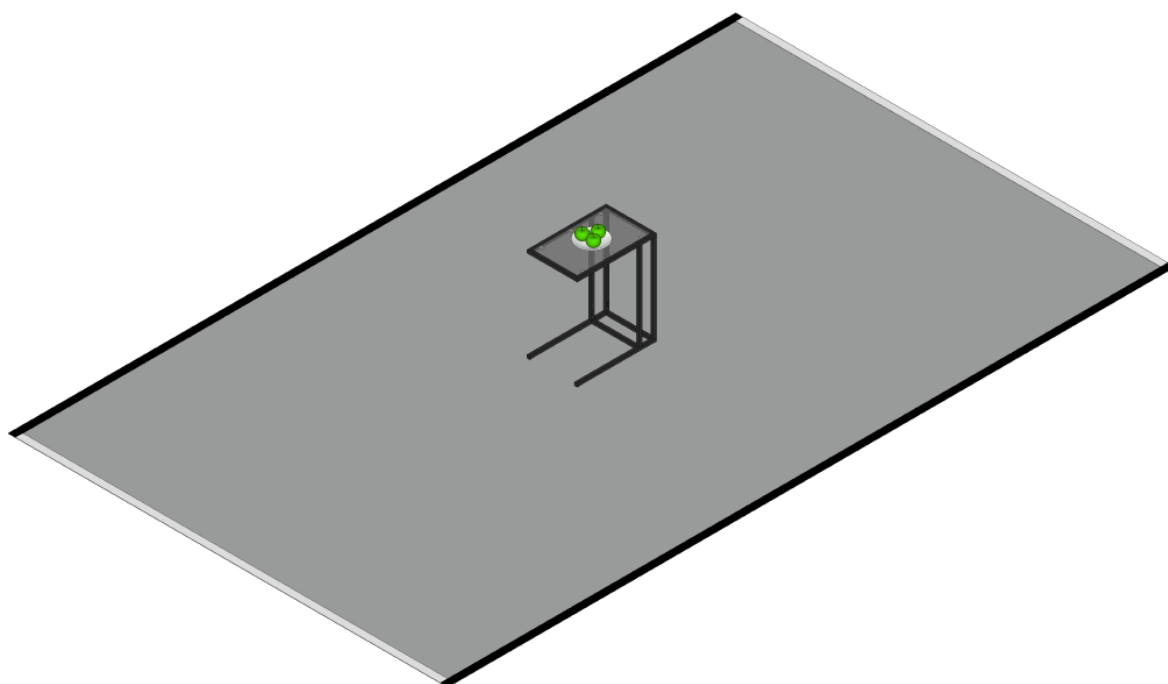
Eating and drinking are situations in which an assistance robot can be of great help to a user. However, such situations pose a particular challenge to the control of the assistance robot. On the one hand, because the involved objects have heterogenic properties (e.g., shape, compliance, texture), on the other hand due the required interaction between the device and the pilot during which safety must be guaranteed at any time.



[Image source](#)

In this task, pilots must use their assistance robot to eat an apple.

8.4.1.2 Task set-up & description



One of the apples must be brought in contact with the pilot's mouth using the assistance robot. The apples are green in the race. ~~but are coloured blue for illustration.~~

8.4.1.3 Task rules

- ROB-EAT-1 The pilots must grasp any of the apples from the **plate** and bring it to their mouth, i.e., they must make contact between their lips and the apple.
- ROB-EAT-2 After making contact between the apple and the pilot's mouth, the apple must be placed on the plate or on the table. If any of the apples touch the table before it was in contact with the pilot's mouth, the task is failed.
- ROB-EAT-3 The pilots are not allowed to actively move towards the apple with their trunk or head as the device approaches the pilot.

8.4.1.4 Comments

- The referee confirms correct task execution.

8.4.2 Clean Up

8.4.2.1 Introduction

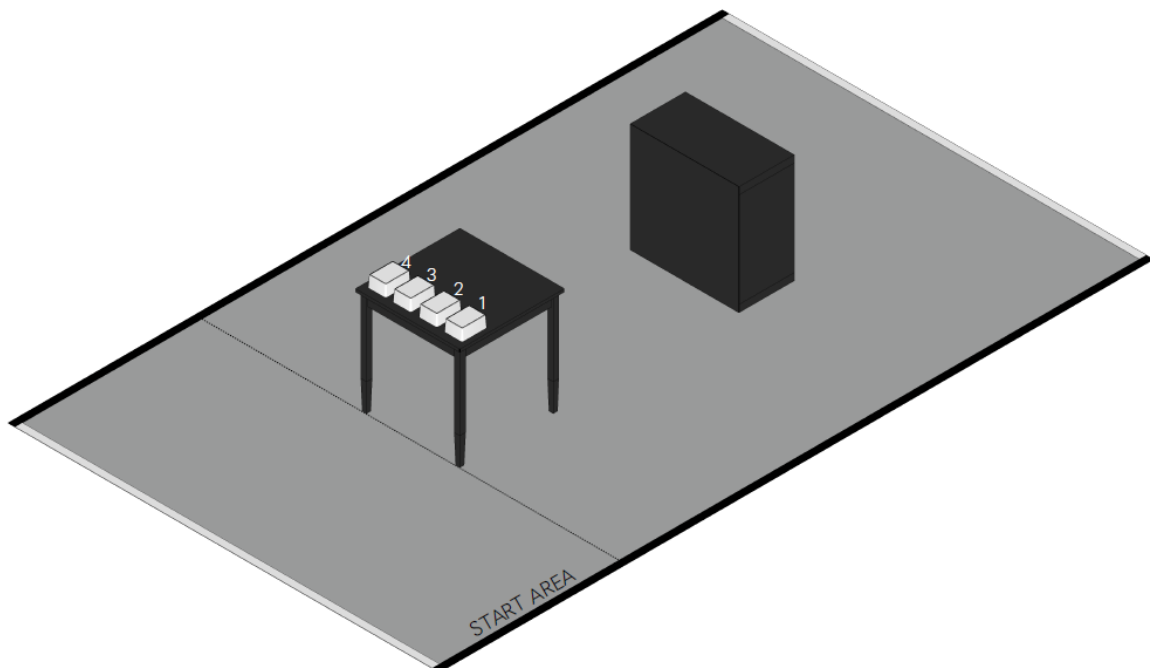
Stowing away objects is a task in which assistance robots can be of significant help to their user. However, the vast variety of objects, their orientation and target locations make this type of task a challenge.

In this task, pilots must clean up a table from several objects and stow them in predefined locations.



[Image source](#)

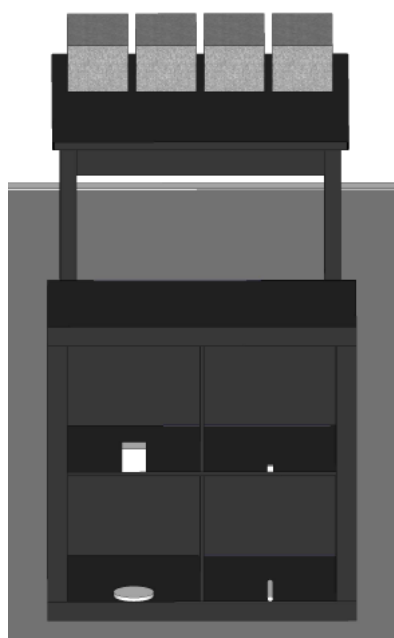
8.4.2.2 Task set-up & description



Initially, four objects are randomly placed on the table and each object is covered by a non-transparent box (1-4).

The same four objects are also randomly placed in the shelf, one object in each of the four compartments (see below). The referee lifts the first **box and puts it down behind**

the uncovered object (towards the finish line). The corresponding object in the shelf must be moved from its compartment to the top of the shelf. Thereafter the referee lifts the second box and so forth.



Left: Initially, the four objects are randomly allocated to the four compartments of the shelf. Right: at the end of the task, the four objects must be located on top of the shelf.



8.4.2.3 Task rules

ROB-CLEAN-1 The objects must be moved from their initial location in the shelf onto the top surface of the shelf in the order in which they are revealed by the referee.

Comment on ROB-CLEAN-1: The boxes are revealed from the right to the left side (1 to 4).

ROB-CLEAN-2 All objects must be located on the top surface of the shelf when the pilot and the assistance robot cross the finish line of the task.

ROB-CLEAN-3 The objects on the table are only revealed by the referee when the pilot's wheelchair, in its entirety, is located in the start area and the previous object has been placed on top of the shelf.

Comment on ROB-CLEAN-3: The pilot needs to go back to the start area for all four objects, although it is clear which object is under box 4.

8.5 Competition mode and scoring

- Points per task: 10
- Total race duration: 4 min

9 Vision Assistance Race



A blind person using an intelligent white cane (Image source: Stefan Schneller, RELab, ETH Zürich, ZHdK)

9.1 Introduction

People with a severe impairment or complete loss of vision lack environmental information compromising their autonomy in completing many activities of daily living across multiple domains. According to the World Health Organisation (WHO), a vision impairment not only impacts quality of life but also leads to lower rates of workforce participation and higher risk of falls. Simple situations such as selecting colour matching clothes or identifying a desired product in the supermarket can become a challenge. Unexpected road work on the daily commute can lead to perilous situations. Generally, unfamiliar, or dynamic environments are challenging to people with a severe impairment or complete loss of vision.

Assistive devices such as smart vision assistants (e.g., an intelligent white cane) are designed to provide information about the environment by rendering the information to other available senses, such as touch or hearing. While there is a wide range of vision aids available on the market using a variety of approaches (e.g., computer vision, artificial intelligence), their functions are usually restricted to specific domains (e.g., reading a text aloud, identifying a colour) or are unpractical to use and therefore do not satisfy the user's needs.

Smart vision assistants that provide an intuitive, comprehensive, and reliable substitute to vision bear the potential to improve the quality of live and autonomy of people with a severe impairment or complete loss of vision.

9.2 Eligibility criteria

In addition to the General Rules outlined in chapter 3, the following specific rules apply for the Vision Assistance Race:

9.2.1 Pilots

Pilots must fulfil the following criteria to be eligible for participation in the VIS race:

- VIS-PIL-1 Pilots must be blind according to the definition of ICD-11, i.e., category 4 or worse in their better eye. This corresponds to pilots presenting with a visual acuity of worse than 20/400 (0.05).

9.2.2 Technology

The assistive device must fulfil the following criteria to be eligible for participation in the VIS race:

There are no specific eligibility criteria in addition to the general rules set forth in chapter 3.

General comments

- Input (control) devices can include any standard or novel technology such as but not limited to BCIs, speech processing methods or any other technology.
- Any technical modality (and their combination) to collect information about the environment is eligible (e.g., LIDAR, vision, ultrasound).
- Any type of feedback modality (e.g., sound, voice, vibro-tactile, electric stimulation) is eligible provided it is safe for the pilot and the environment.
- At the competition site, there might be applause and cheering. The noise level may vary within and between different races.

9.3 Specific race rules

VIS-1 All Pilots **with remaining vision** will be completely blindfolded during the competition. The blindfold must be applied according to the guidelines provided by the CYBATHLON organising committee.

VIS-2 A team official can accompany the pilot to the competition field. Once the race has started the accompanying team official is not allowed to interact with the pilot or the assistive device in any way (i.e., coaching is not allowed) In case of any intervention during the race (e.g., in case of coaching, a technical defect or an emergency) the race is terminated for that pilot. The pilot's current score is then taken as the score for that race.

VIS-3 After a task fail or to skip a task, pilots can call the accompanying team official for assistance. The accompanying team official must guide the pilot to the middle of the start line of the next task (behind the start line - not on the start line).

VIS-4 As soon as pilots and accompanying team officials have left the callroom, i.e., can see the racetrack, pilots and accompanying persons are not allowed to talk anymore.

Comment on VIS-4: This rule prevents that the accompanying team official provides information to the pilot about the configuration of the objects on the tasks that shall remain unknown prior to the race.

9.4 Task definitions

Each task is described in the following sections. If not otherwise defined, the direction of the race is (bottom) left to (top) right in all the following figures.

9.4.1 Sidewalk

9.4.1.1 Introduction

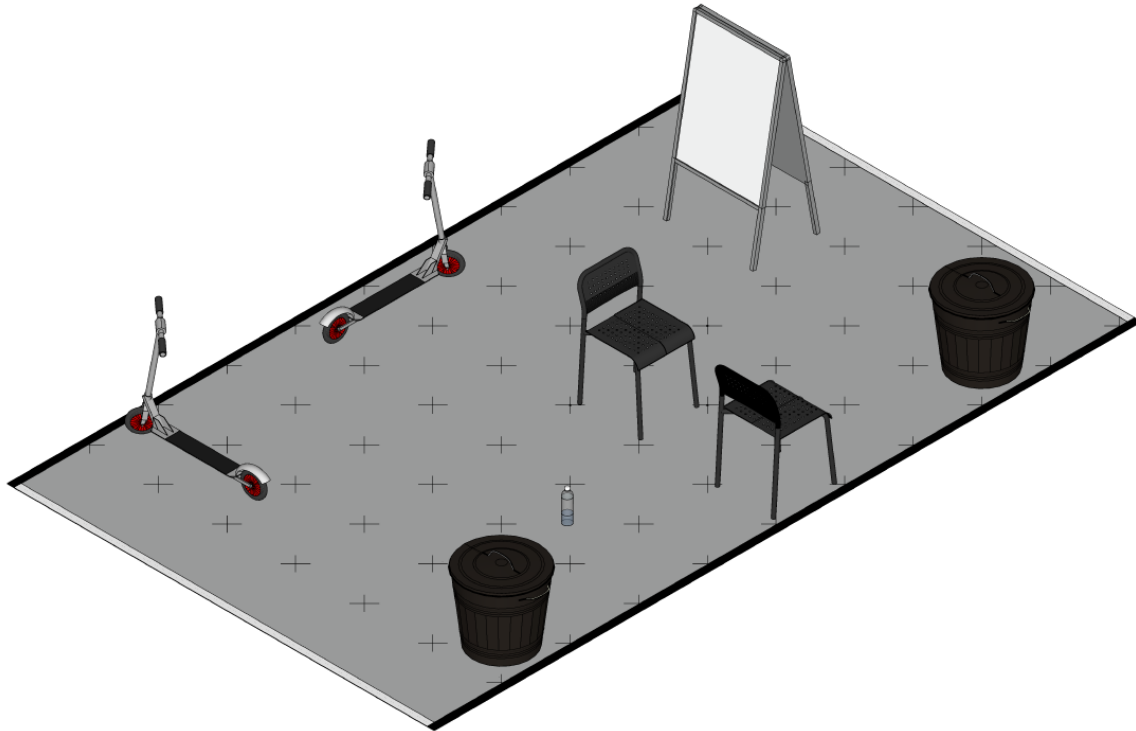
When walking in a public space, blind people are often confronted with physical obstacles (e.g., an e-scooter that is carelessly left on a sidewalk, a tree branch lying on the ground). This may lead to collisions and falls.

In this task, pilots must negotiate a set of obstacles obstructing their path.



[Image source](#)






9.4.1.2 Task set-up & description



Pilots must negotiate a set of obstacles that obstruct their path. The objects are randomly placed on the task space.

The obstacles are placed according to the following rules:

- The task space is divided into a virtual grid of 9 (1-9) columns and 6 rows (A-F).
- Up to ten (5x2) objects (see below) are randomly placed on the grid on the task space. The same subset will be used for all races of a given round.
- All objects are placed upright.
- The objects can be placed in four orientations: facing left or right sideline, facing start or finish line of the task.

				
Chair	PET bottle	Scooter	Waste bin	Customer stopper

9.4.1.3 Task rules

VIS-SIDE-1 The pilot must walk from the start to the finish line of the task.
 VIS-SIDE-2 If any of the objects is touched, the task is failed. This includes touching of the objects with a white cane or any other assistive device.

9.4.1.4 Comments

- Pilots are free to choose their path from the start to the finish line.
- It is allowed but not necessary to step over objects to reach the finish line.
- There are always two paths without an obstacle. The path width is at least one square.

9.4.2 Serving Food

9.4.2.1 Introduction

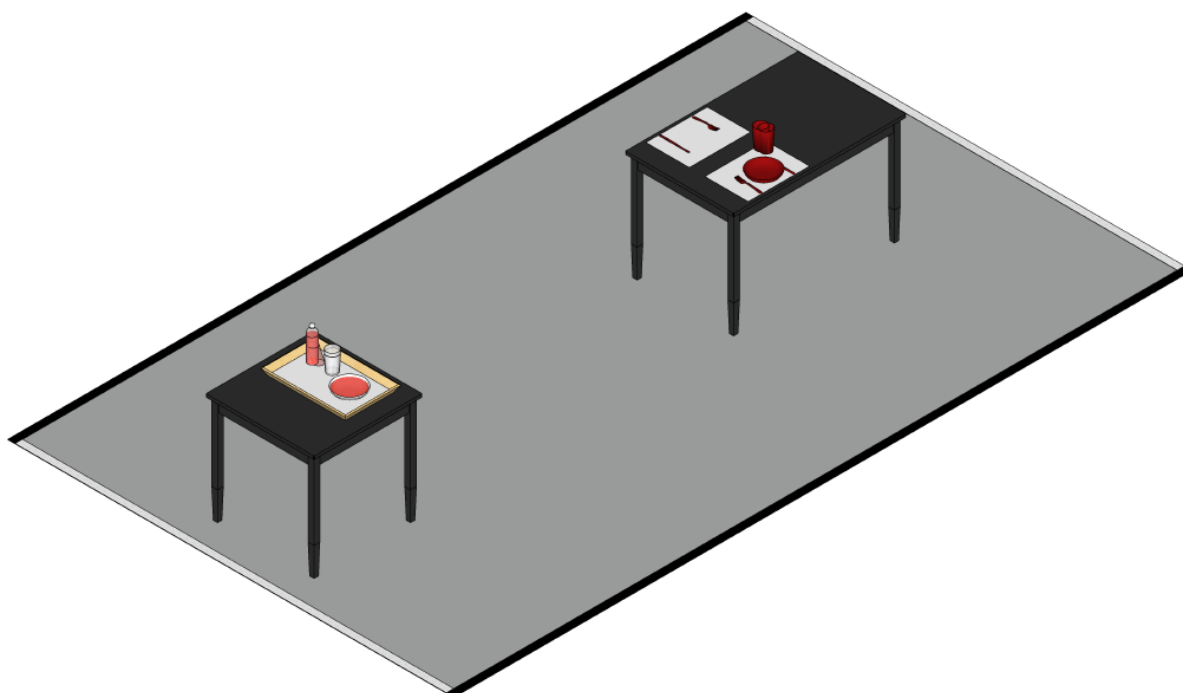
Serving food is a challenge for blind people since plates and glasses must be kept horizontal to make sure that contents are not spilled while walking.

In this task, pilots must serve food and place it at table.



[Image source](#)

9.4.2.2 Task set-up & description



The pilots must place a drink and a soup plate at the correct location at the table near the finish line, i.e., on the table mat with the empty space for the glass and soup plate.

The target locations for the glass and the soup plate can face the left or the right side of the track. The bottle is initially closed with a bottle cap.

9.4.2.3 Task rules

VIS-SERVE-1 The glass must be filled at least to the mark (2 cm below rim or the glass). If the filling of the glass is below the mark when passing the finish line, the task is failed.

Comment on VIS-SERVE-1 The pilots are allowed to fill the glass at any location, e.g., at the table near the start line or near the finish line.

Comment on VIS-SERV-1 It is not allowed touch the liquid with a sensor or any other part of the body or device. The idea is not to touch food or drinks.

VIS-SERVE-2 It is allowed to carry the filled glass, the soup plate, and/or the bottle using the tray or without using the tray.

VIS-SERVE-3 The filled glass and the soup plate must be located at their target location on the table mat when the pilot crosses the finish line of the task. The base of the glass and soup plate must be on the table mat with its entirety.

VIS-SERVE-4 The tray and the bottle must be located on the table, but not on the table mat and not touching the table mat, when the pilot crosses the finish line of the task.

VIS-SERVE-5 The bottle cap must be on the bottle when the pilot crosses the finish line of the task.

VIS-SERVE-6 If any of the **red** content of the glass or of the soup plate is spilled, the task is failed.

VIS-SERVE-7 The **red** tableware and cutlery that are initially placed on the table must not be touched or moved by the pilot or another object moved by the pilot.

9.5 Competition mode and scoring

- Points per task: 10
- Total race duration: 4 min

Appendix I: Competition Infrastructure

This separate document contains all relevant information to rebuild the competition tasks.

The current version is **V 1.3.**

Find the Appendix I here for download:

<https://cyathlon.ethz.ch/en/projects-events/challenges/CYBATHLON-Challenges-2023/team-registration>

Appendix II: Appeals

This separate document contains all relevant information related to the appeals procedures.

Find the Appeals document here for download:

<https://cybathlon.ethz.ch/en/projects-events/challenges/CYBATHLON-Challenges-2023/team-registration>