4th Kibo Robot Programming Challenge

Guidebook

Version 1.0 (February 20, 2023)

Japan Aerospace Exploration Agency (JAXA)

Revision History

Details regarding changes made to the document are shown below.

Revision Date	Version	Paragraph(s)	Rationale
February 20, 2023	1.0	All	—

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1. Introduction

1.1. Kibo-RPC

The Kibo Robot Programming Challenge (Kibo-RPC) is an educational program in which students will solve various problems by moving free-frying robots (Astrobee and Int-Ball) using their programming skills in a simulation environment and, in the final, in the Japanese Experiment Module (Kibo*) aboard the International Space Station (ISS).

Through interaction with experts in the field of space and the opportunity to observe their work firsthand, students will be able to deepen their understanding and acquire specialized scientific knowledge.

Through this educational program, it is our hope students will take the initiative to learn the techniques and methods involved in programming and robotics, while honing their STEM (science, technology, engineering and mathematics) skills.

This program is hosted by the Japan Aerospace Exploration Agency (JAXA) in cooperation with the National Aeronautics and Space Administration (NASA).

*Kibo is pronounced "key-bow" and means "hope" in Japanese.

1.2. Educational Objectives

In this program, by moving actual robots in the ISS based on hypotheses simulated in advance, students will learn about the importance of bridging the gap between simulation and reality when programming.

Students will learn to create programs that are robust enough to handle uncertainties and errors that cannot be easily simulated, such as external disturbances, and which work well in the real world. Through simulations, they will learn the need for multiple program revisions, attitude control for free-flying robots, and how to conduct missions within the ISS.

In the 4th Kibo-RPC, the position of the target will change randomly, which will require real-time processing and make the game rules more challenging than in previous competitions.

1.3. ISS Robots

The ISS is equipped with Astrobee free-flying robots and Int-Ball[1], a spherical camera drone. In the Kibo-RPC, students will create a program to move an Astrobee to designated locations within Kibo.

[1] Int-Ball will not be used in the competition.

Astrobee

Figure 1.3-1 Astrobee

Astrobee is NASA's new free-flying robotic system that will help astronauts reduce the time they spend on routine duties, leaving them to focus more on the things that only humans can do.

Working autonomously or via remote control by astronauts, flight controllers, or researchers on the ground, the robots can perform tasks such as taking inventory, documenting experiments, or moving small items or cargo throughout the station.

(https://www.nasa.gov/astrobee)

Int-Ball

Figure 1.3-2 Int-Ball

Int-Ball is a free-flying camera drone designed to ultimately eliminate the need for crew members to capture routine video footage aboard the ISS/Kibo.

Similar to current consumer-grade cameras, Int-Ball is used by on board crew to provide flexible views for ground operators.

Int-Ball is perhaps the first human-friendly camera robot in space.

(https://fanfun.jaxa.jp/topics/detail/10536.html)
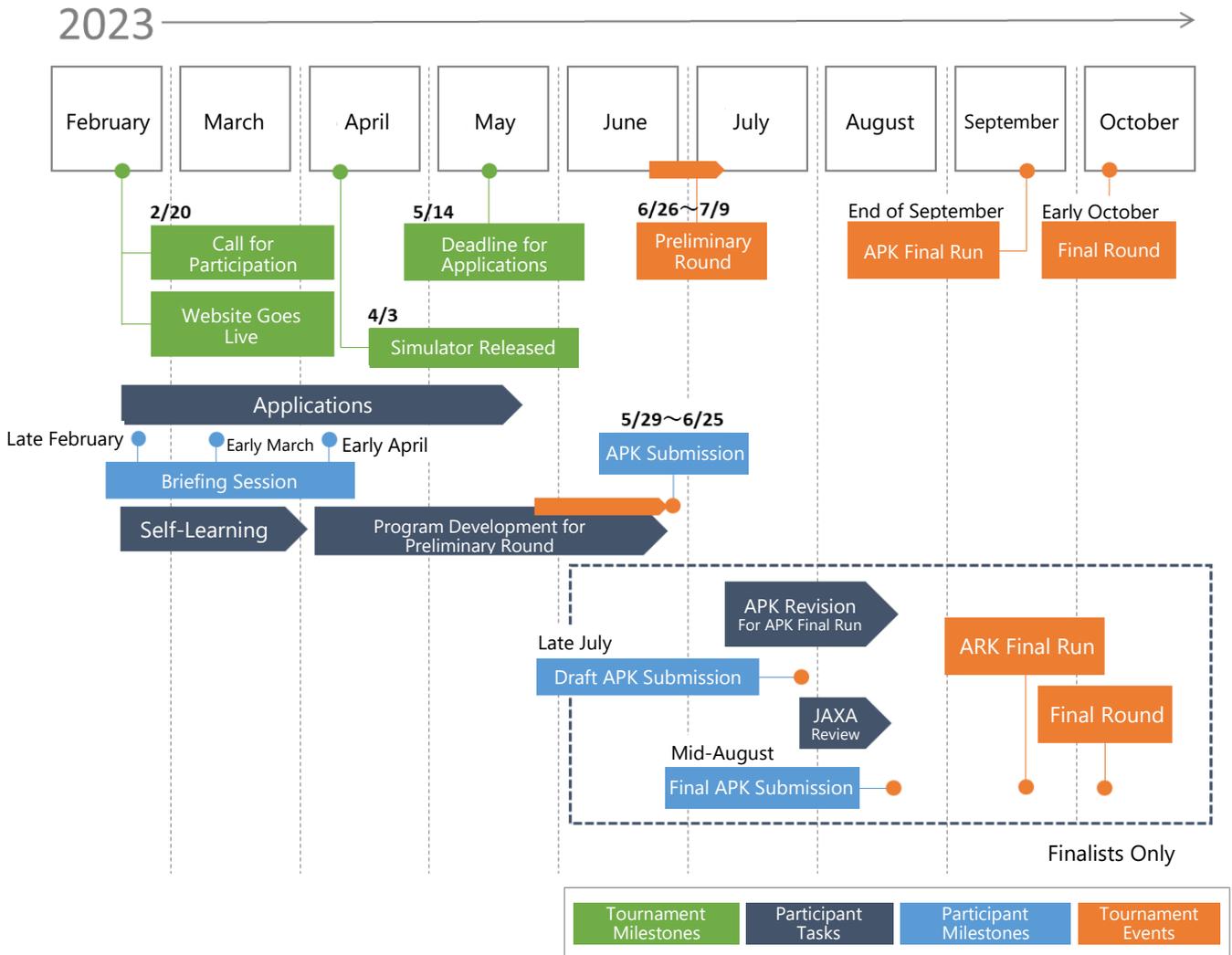
2. Event Information

2.1. Event Schedule

Figure 2.1-1 Event schedule

Table 2.1-1 Description of events *Dates are subject to change.

Item	Content
Call for Participation	**February 20 – May 14, 2023** ・ A Kibo-RPC briefing session will be held during this period.

Item	Content
Self-Learning	**February – April 2023** · Participants may access the Github repository provided by NASA to learn how to program Astrobee. ➢ GitHub-1 (https://github.com/nasa/astrobee) ➢ GitHub-2 (https://github.com/nasa/astrobee_android) ➢ Astrobee website (https://www.nasa.gov/astrobee) · Tutorial videos can be found on the Kibo-RPC website. (https://jaxa.krpc.jp/index_ja.html)
Program Development	**April – June 2023** · Using the web-based simulator, which is scheduled for release in early April, participants will develop their programs for the preliminary round. · A rule book containing detailed game rules will be released at the same time as the simulator.
Preliminary Round	**June 26 – July 9, 2023** · **Please participate in the preliminary round hosted by the space agency in your country/region.** · Please develop and upload your Android Package Kit (APK) **through the web-based simulator by the submission deadline**. · The winning team from each country/region will advance to the APK Final Run, which will take place aboard the ISS. ➢ Please note that there may be further restrictions on the number of teams that can participate in the APK Final Run on the ISS. The number of teams and the selection method will depend on astronaut schedules and will be announced at a later date. · The competition will be judged by the space agency in each country/region based on scoring elements, game rules, and individual evaluation criteria set by JAXA. · Details such as location and schedule will be announced by each country/region's space agency.
APK Revision (Finalists only)	**Mid-July – Early August 2023** · Finalists in the APK Final Run **must revise their programs** before installing them on Astrobee. · The APK Final Run Simulator is scheduled to be released right after the preliminary round. · Teams must submit a draft of their program in late July. JAXA will conduct a review of the program content from a safety perspective during the draft stage. **If there are any problems, the representative's team will have to modify their program according to JAXA's instructions. Please note that the schedule is tight.** · The deadline for submitting the final version of the program is **early August**. (Don't be late. More information will be released later.)
APK Final Run	**Mid – Late September 2023** · Finalists' programs will be installed on ISS Astrobee for the competition. Only the runs of your own team will be **available for online viewing** and at this point there will be no announcements regarding scores or ranking.
Final Round	**Early October 2023** · **The results and ranking of each finalist's games in the APK Final Run will be announced.** · The competition will be judged based on the scoring elements and game rules set by JAXA. · The event will be live-streamed on YouTube.

2.2. Website and Simulation Environment

The web-based simulation environment will be prepared in phases.

Table 2.2-1 Release schedule

Event	Date
Programming Manual	April 3, 2023
Rule Book	April 3, 2023
JAXA Web-based Simulation Environment	April 3, 2023
Simulation Environment Update for APK Final	Mid July, 2023

The website of previous Kibo-Robot Programming Challenge

1st : https://humans-in-space.jaxa.jp/krpc/1st/index.html
2nd : https://humans-in-space.jaxa.jp/krpc/2nd/index.html
3rd : https://humans-in-space.jaxa.jp/krpc/3rd/index.html

3. Kibo-RPC Entry Application

3.1. Entry Requirements

Students who live in one of the Kibo-ABC member countries/regions*1 or the US and who are enrolled in a school up to graduate school in a country/region*2 participating in Kibo-RPC (including foreign students) are qualified to enter. Exceptions may be made in cases such as those shown below if approved by the Point of Contact (space agency) (POC) of the country/region participating in the Kibo-RPC in which they reside. If you think that applies to you, please contact your POC.

Special Cases

(1) Non-students may be eligible to compete, as long as they are not professional programmers.

(2) Students studying outside their country may be allowed to form a team representing their country in the place in which they are studying.

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*1 Kibo-ABC member countries/regions (listed in alphabetical order).
Australia, Bangladesh, Indonesia, Japan, Malaysia, Nepal, New Zealand, the Philippines, South Korea, Singapore, Taiwan, Thailand, United Arab Emirates, and Vietnam.
Kibo-ABC URL: https://humans-in-space.jaxa.jp/biz-lab/kuoa/kibo-abc/

*2 Countries/regions participating in the 4th Kibo-RPC (as of February 2023).
Australia, Bangladesh, Japan, Malaysia, Nepal, Singapore, Taiwan, Thailand, United Arab Emirates, the United States

This competition is open to teams in cases 1, 2, and 3 listed in Table 3.2. If your team includes students who are citizens of a country/region participating in the 4th Kibo RPC or who belong to schools in that region, you may participate in this competition.

Table 3.1 Team formation

Case	Nationality of participants	Location of their school	Participation
1	Kibo-RPC participating country/region	Kibo-RPC participating country/region	✓
2	Kibo-RPC participating country/region	Kibo-RPC non-participating country/region	✓
3	Kibo-RPC non-participating country/region	Kibo-RPC participating country/region	✓
4	Kibo-RPC non-participating country/region	Kibo-RPC non-participating country/region	—

3.2. Team Formation Rules

(1) Team Structure

- A team must comprise of three (3) or more members (guardians do not count as members).
- No student may belong to multiple teams.
- After the preliminary round is over and the national team has been selected by the POC, team members may not be changed.

(2) Team Leader

- Each team must have a leader who is responsible for team management. The team leader may be a student in the team, or a guardian (or a teacher) of the team member(s).
- The team leader has the following responsibilities:
  - ✓ Manage the team's programming progress
  - ✓ Submit applications
  - ✓ Submit programs
  - ✓ Communicate and share information with the POC in the country/region

(3) Other Conditions

- The following skills and knowledge are desirable, but not required.
  - ✓ Android programming and Java image processing
  - ✓ College-level knowledge of physics and mathematics
- When applying, please be sure to review the contents of the attached Kibo-RPC Entry Agreement and tick the consent confirmation box on the Application Form.

3.3. Application

(1) Select the application URL for your country/region on the Kibo-RPC website (https://jaxa.krpc.jp/), fill in the form and submit it. Required items are shown below. We recommend that you have the details ready before you start.

- ✓ Team Name (English):
- ✓ Team Leader: Name (English), age, nationality, affiliation, address, phone number, and email address.
- ✓ Team Members: Name, age, nationality, affiliation, history of past participation in Kibo-RPC.
- ✓ How you came to know about Kibo-RPC.
- ✓ Consent to the Terms of Participation.

(2) Once your application has been accepted, you will receive an email containing your log-in ID and password to enable you to access JAXA's web-based simulator and the participants' page on the Kibo-RPC site.

Please allow three (3) business days for your registration to be completed.

Deadline for Applications: May 14, 2023

4. Game Information

4.1. Scenario

Sometime between 2020 and 2022, meteors and space debris hit the ISS causing air leaks and damage to the exterior walls. These problems were resolved through the efforts of young student programmers from Asia.

In 2023, data confirmed by ISS telemetry indicated a suspected ammonia leak into the spacecraft from Kibo's control systems. Ammonia is normally used as a coolant for the external thermal control system, but some had entered the spacecraft through the internal thermal control system via the heat exchanger. This internal thermal control system showed signs of an increase in coolant fluid levels, turning the ammonia to gas, leading to an increase in pressure in the cooling water pipes, and eventually causing leaks in the pipes.

As ammonia is harmful to the human body, the ISS astronauts began to evacuate in accordance with emergency procedures. Kibo was sealed off and isolated from the other modules of the ISS. However, inside Kibo, an Astrobee capable of autonomous operation was still operating normally.

The location of the leaks increased randomly over time due to the increase in pressure in the cooling water pipes.

Mission

Use Astrobee's laser to fix the leaks.

*Please note that this story is fiction.

4.2. Game Overview

Move Astrobee from the starting position (docking station) to multiple active targets and use Astrobee's laser to hit the target within the time limit. When you have finished, report "mission completed" to the astronaut. The program will be evaluated based on the total points obtained from laser targeting.

4.3. Game Flow

① Start from the docking station.

② At the start of the program, 1-3 targets will be activated.

③ Move towards the activated targets while avoiding Keep Out Zones (KOZ) and hit the targets with the laser.

④ Different targets will be randomly activated during the game based on laser targeting performance and elapsed time.

⑤ Reset the course and targets as changes occur, repeating step ③ until the time is up (5 minutes).

⑥ Go and report "mission completed" to the astronaut **within the time limit**[*2] using Astrobee's Signal Lights.

*1 Keep Out Zone (KOZ): Astrobee is unable to enter these areas. If you attempt to enter a KOZ you will be denied entry.

*2 Time Limit: Five (5) minutes including the time to report mission completion.
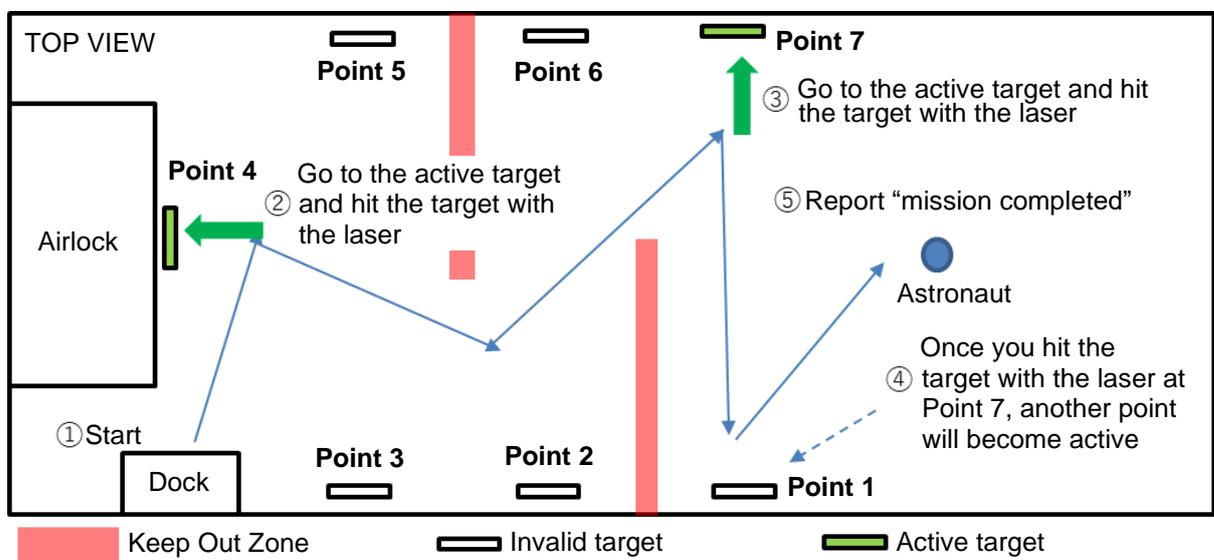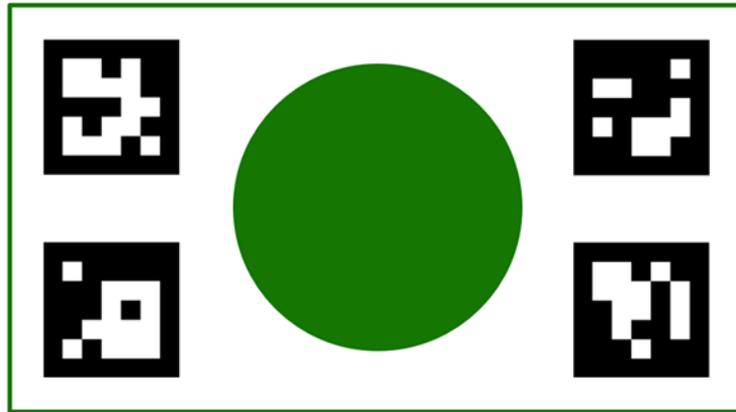

Figure 4.3-1 Game flow

Figure 4.3-2 Target example

4.4. Evaluation Standards

Programs will be evaluated based on the total number of points scored through laser targeting within the specified time.

In the preliminary round, simulations are run using multiple patterns that vary in random elements (such as the order in which active points change and the number of AR markers). Your score will be the average of the scores obtained from multiple games, unlike previous Kibo-RPCs which took the worst score. For details, please see the Kibo-RPC Rule Book, which will be released in April.

4.5. Information to be Released Later

The following information is scheduled to be released in the Kibo-RPC Rule Book in April 2023.

1. Starting position and orientation
2. Orientation of each point
3. KOZ coordinates and size
4. Target size
5. AR tag size
6. Conditions for changing activated points

Terms and Conditions

Applicants must agree to all of the terms below. If you live in the EU, please agree to the contents of the attached materials.

1. Privacy Policy

(1) Collected personal information will only be used for the operation of the Kibo-RPC.
(2) The videos and photos taken at this tournament will be made publicly available.

2. Responsibility of Applicant and Exemption Clause of JAXA

(1) JAXA will not be liable for any problems that may occur during program participation.Applicants need to take full responsibility for solving issues of this nature that may arise
(2) Applicants must guarantee that information on the application form and the program code do not violate any legal rights or obligations, such as intellectual property or export control,as applicable. If a legal problem related to the submitted information arises, the applicant will take full responsibility to solve the problem
(3) If there is a violation of these matters registration may be canceled, even after registration.

3. Notes

(1) Underage applicants must first obtain parental consent.
(2) Do not use the simulator environment provided in the Kibo-RPC for any purpose other than the Kibo-RPC. Sign-on information for accessing the simulator environment will be made available only to the competition applicants. Do not disclose this information to anyone else.
(3) JAXA may use the program codes and results of the competition for the purpose of public relations and education.

Consent content based on EU GDPR

For the purposes of notification of competition information, Sending of prize certificates and commemorative gifts, provide information to POC in countries/regions other than Japan for the purpose of managing the event, JAXA needs to collect your personal data requested in the present form.
You may at any time object to the use of your data for this purpose by writing to the following address:
Z-KRPC@ml.jaxa.jp

You will find below all the detailed information concerning this processing of your personal data and a reminder of your rights, in application of the legislation in force.
JAXA, willing to respect the privacy and protection of personal data of its prospects and clients, complies with the legislation in force regarding the protection of personal data as data controller, and in particular Law no. 78-17 of 6 January 1978 (the "Data Protection Act") and, from 25 May 2018, Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of individuals with regard to the processing of personal data and the free movement of such data (the "GDPR").

PLEASE BE INFORMED THAT THE PERSONAL DATA WILL BE TRANSFERRED TO JAPAN AND POC AND TEAM OF THE PARTICIPATING COUNTRIES/REGIONS FOR THE PURPOSE AS DESCRIBED ABOVE.

You have, under the conditions defined by the Data Protection Act and the GDPR, unless otherwise provided:

(i)   The right to withdraw at any time your consent to the processing implemented by JAXA based on such consent ;

(ii) The right to obtain from JAXA the confirmation that your personal data are or are not processed and, when they are, access to said personal data as well as to several information on the processing (processing purposes, categories of personal data concerned, recipients or categories of recipients to whom your personal data have been or will be communicated, the retention period of the personal data envisaged or, where this is not possible, the criteria used to determine this duration, etc.)

(iii) A right of access, rectification and/or erasure of your personal data;

(iv) The right to receive your personal data provided to JAXA, in a structured, commonly used, and legible format, and the right to transfer this data to another data controller without JAXA having to obstruct it;

(v)   A right of opposition, for legitimate reasons, to the processing of your personal data and the right of opposition to the use of such personal data;

(vi) The right to request from JAXA the portability of your personal data in the event you wish to obtain the transfer of your personal data to the benefit of another data controller.

You can set, change and revoke at any time guidelines for the retention, erasure and communication of your personal data after your death. You have the right to appoint a third party to whom your data may be communicated after your death. You agree to inform this third party of your approach.

You may exercise the rights described above by writing to JAXA at the following email address:

Z-KRPC@ml.jaxa.jp