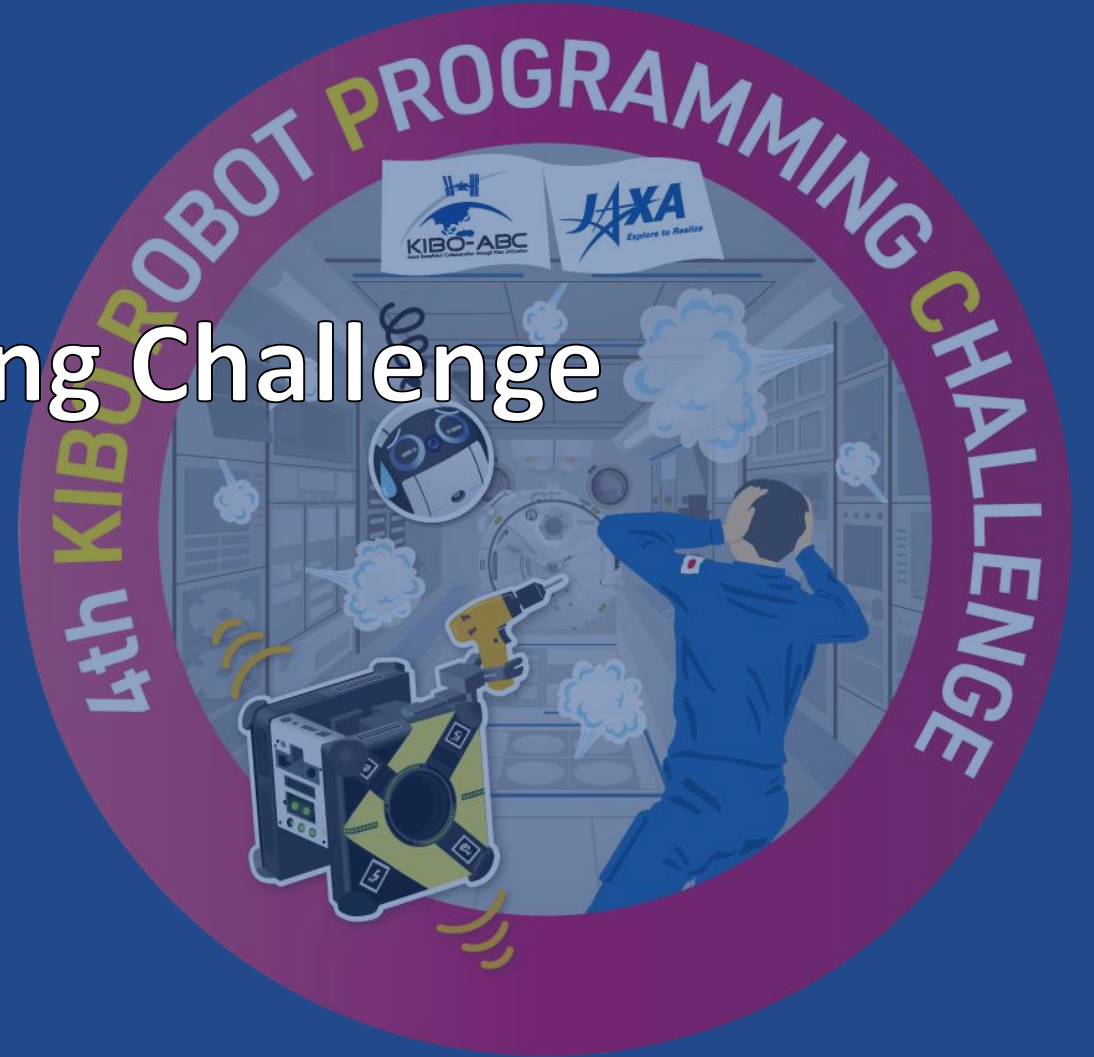


4th Kibo Robot Programming Challenge Overview

June 1st, 2023
Astrobee Working Group

Kibo-RPC secretariat
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Japan-U.S. Open Platform Partnership Programs (JP-US OP3)

- ❑ On December 22, 2015, the Japanese and U.S. governments agreed on a new cooperation framework for the ISS Program.
 - ✓ Japan decided to extend its participation in the ISS operations until 2024.
(Now Japan expressed its extension to 2030)
 - ✓ An outline of JP-US OP3 is as follows:

1. Promotion of mutual use of experiment facilities
2. Increased cooperation in the Asia-Pacific region
3. Promotion of new uses for the ISS: technology demonstration, and use of HTV and HTV-X
4. Promotion of use of effective and efficient space-related technologies



**JAXA and NASA are pursuing implementation of JP-US OP3.
Kibo-RPC is based on JP-US OP3.**

About the Kibo Robot Programming Challenge

- ❑ The Kibo Robot Programming Challenge is **an educational program**.
 - ✓ Students solve various problems by **programming free-flying robots (Astrobee and Int-Ball) in the International Space Station (ISS)**.
- ❑ Participants will have the chance to learn cutting-edge methodologies and **to hone their skills in science, technology, engineering and mathematics (STEM)**.
- ❑ **Expand international exchange by encouraging students** to interact with other participants from around the world.
- ❑ **To expand Kibo utilization in the Asia-Pacific region**, an educational program for operating robots and computer programming is being offered to students in Japan and the Asia-Pacific region.

Educational objectives of the Kibo Robot Programming Challenge are to learn :

- ❑ The techniques for creating simulation programs that **perform well in the real world despite uncertainties and within margins of error.**
- ❑ The necessity of **controlling and correcting positions and orientation** of a free-flying robot.
- ❑ **How to perform assigned tasks in the onboard environment** through simulation trials.

Automation and autonomy technologies are essential for future human space activities in low Earth orbit, and we aim to develop human resources with these skills (STEM education) through this program.

About the past Kibo-RPC activities

□ Entry Qualification

- ✓ Students up to graduate school in a Kibo-RPC participating country/region under the framework of Kibo-ABC may apply for the competition.

□ 1st Kibo-RPC (2020)

- ✓ 7 countries/regions
- ✓ 313 team - 1168 people

□ 2nd Kibo-RPC (2021)

- ✓ 11 countries/regions
- ✓ 286 team - 905 people

□ 3rd Kibo-RPC (2022)

- ✓ 12 countries/regions
- ✓ 351 team - 1431 people



The 4th Kibo-RPC Participation

As of June 7

Country / Region	Teams	Participants
Australia	3	
Bangladesh	76	
Japan	27	114
Malaysia	12	54
Nepal	1	10
Singapore	6	23

Country / Region	Teams	Participants
Taiwan	29	116
Thailand	182	718
United Arab Emirates	9	37
Vietnam	1	4
The United States	26	105
UNOOSA	50	150

Total: **422** teams
: **1331** participants
(Not include some countries)

The 4th Kibo-RPC Game Story

Game Story

The air leak caused by the space debris impact was repaired by a talented student programmer, and peace returned to the ISS.

However, in 2023, an alert was confirmed from Kibo's control unit that ammonia, which is used as a refrigerant for the external control system, was suspected to have leaked into the ISS.

The number of leakage points increased randomly over time due to increased pressure in the coolant piping.

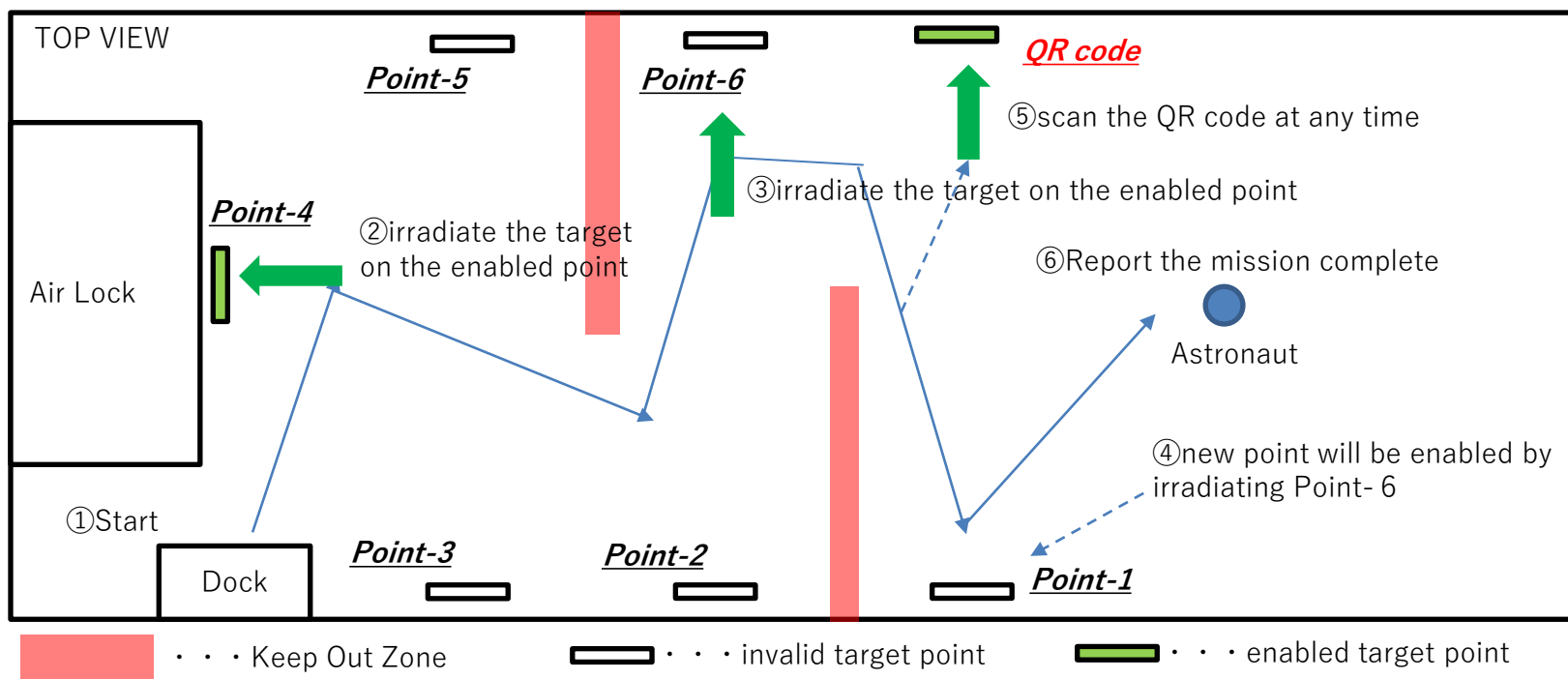
Repair the leakage points by laser irradiation of Astrobee!



※ This is a fictional story.

Game Flow

- ① Start from the Dock station
- ② One to three of the multiple Points are activated. (Unknown until the Program is performed)
- ③ Move toward a enabled Point and irradiate a laser toward the target.
- ④ The enabled Points will change with the time-lapse or laser irradiation as triggers. Repeat step (3) until the time limit(5min) expires, while resetting the path and target in response to the changes.
- ⑤ Scan the QR code at any time
- ⑥ Within the time limit, move to the crew and inform the crew of the completion of the mission

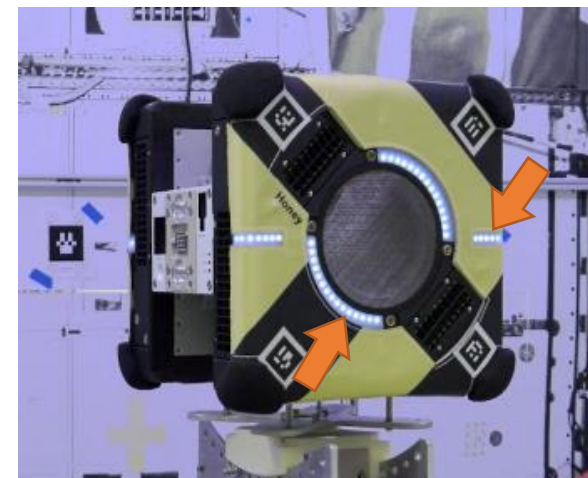


Mission Completion Report

- Mission completion Report with Signal Lights and Perching Arm
 - This is the first time JAXA is utilizing LEDs and the arm.
- Mission Completion Sequence

(The crew hands a sponge ball to Asteobee before each run.)

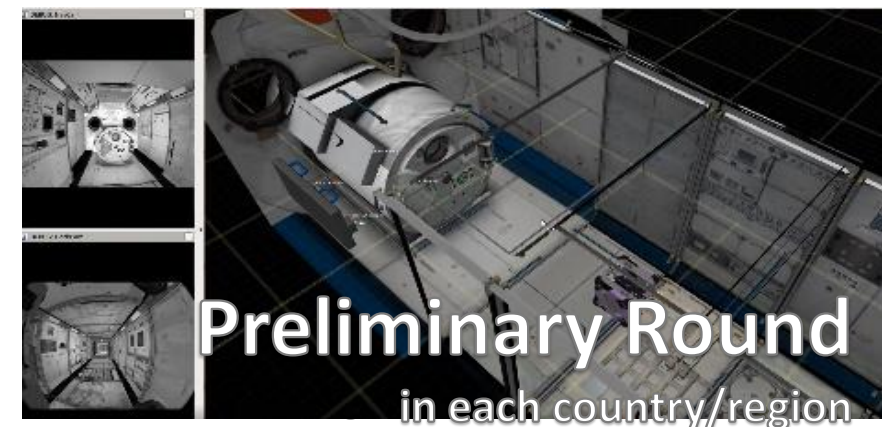
 - Based on the information obtained from the QR code, the appropriate signal light pattern is selected from a predetermined set of patterns.
 - If the information is **correct**:
 - While the **Signal Lights are illuminated**, the arm is extended to **release the sponge ball**.
 - The crew catches the ball.
 - If the information is **incorrect**:
 - Only the signal lights are illuminated.



Event overview

□ Preliminary Round

- ✓ Held in each country/region using simulator.
- ✓ Program **stability** and **robustness** are important
 - ✓ under 10 conditions with different random noise.
 - ✓ the average score out of 10 simulation is assigned.
- ✓ The winning teams will advance to the Final Round as the representatives of their own countries/regions.

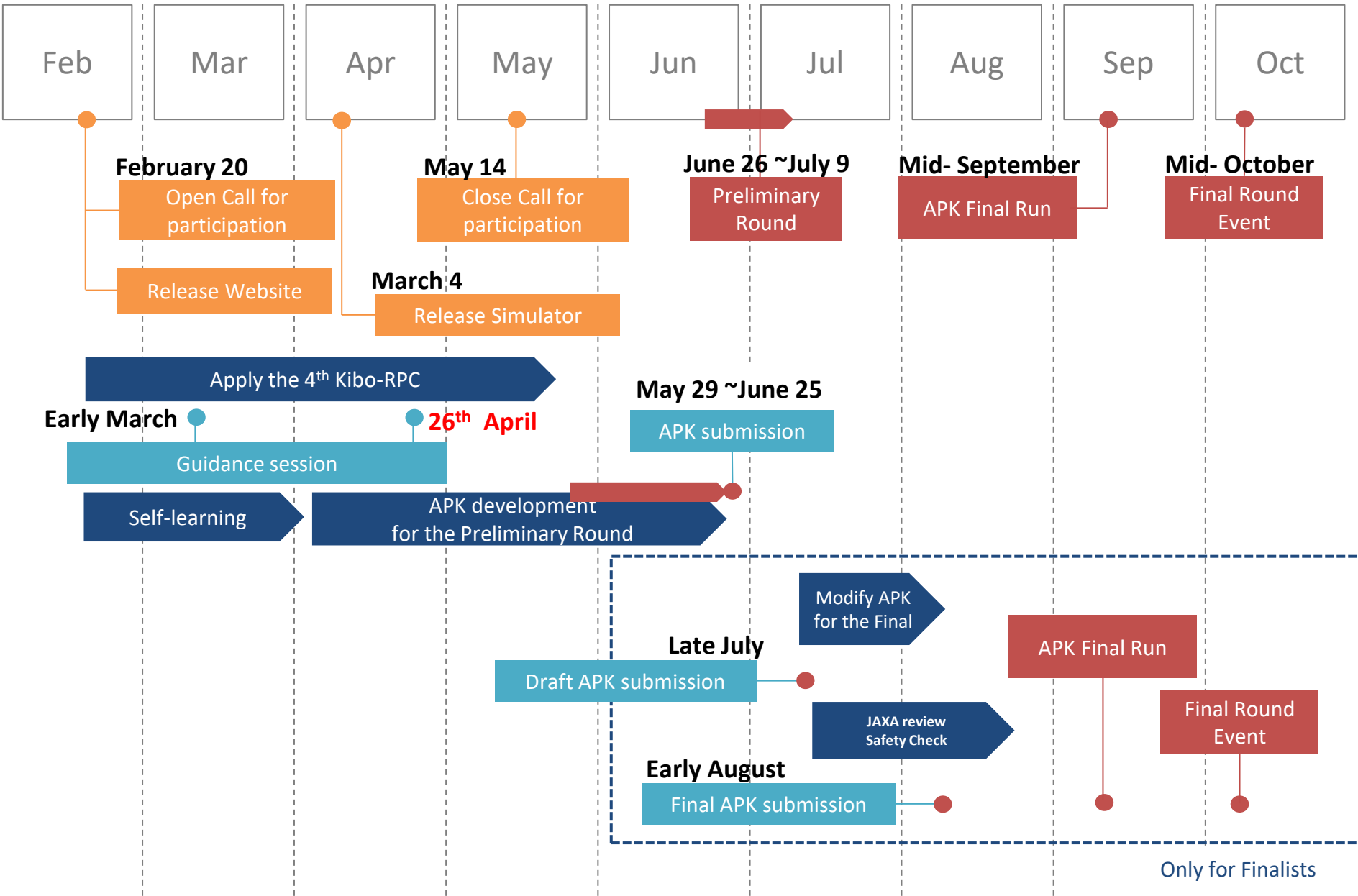


□ Final Round

- ✓ Held in the ISS/Kibo module.
- ✓ Finalists' programs will be installed on Astrobee on-board.
- ✓ There are two events in the final round; the APK Final Run and the Final Round event.

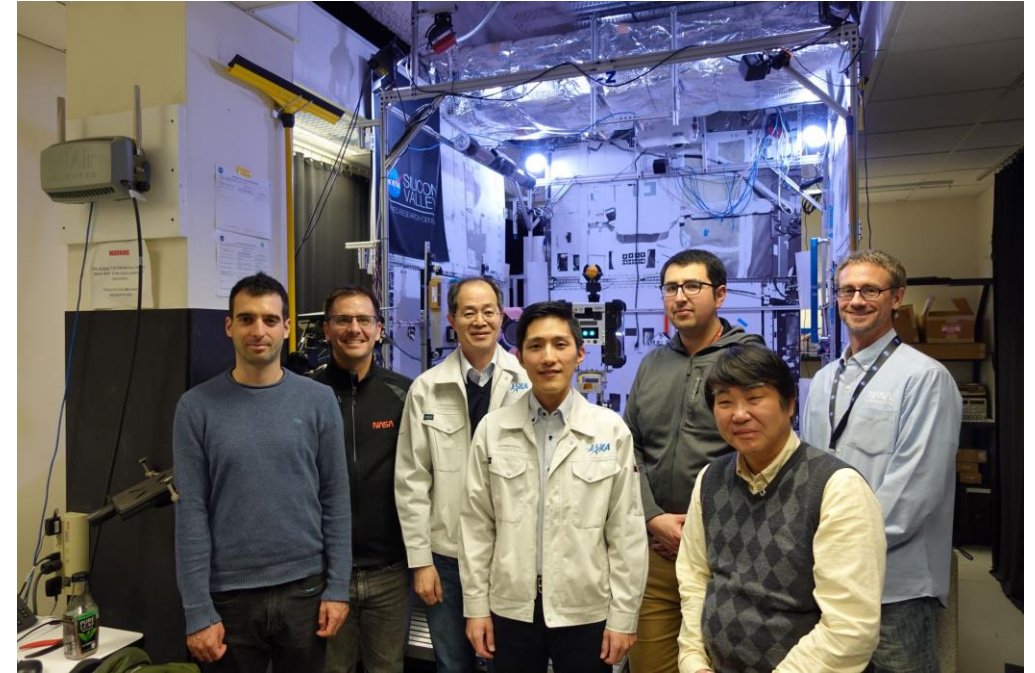


Schedule



Acknowledgement

- Once a year, the JAXA technical team visits NASA Ames Research Center to inspect the configurations and movement of Astrobee.
- JAXA would like to extend our heartfelt gratitude to the Astrobee Facility Team at NASA Ames for their invaluable support and outstanding collaboration!



Thank you for listening!

