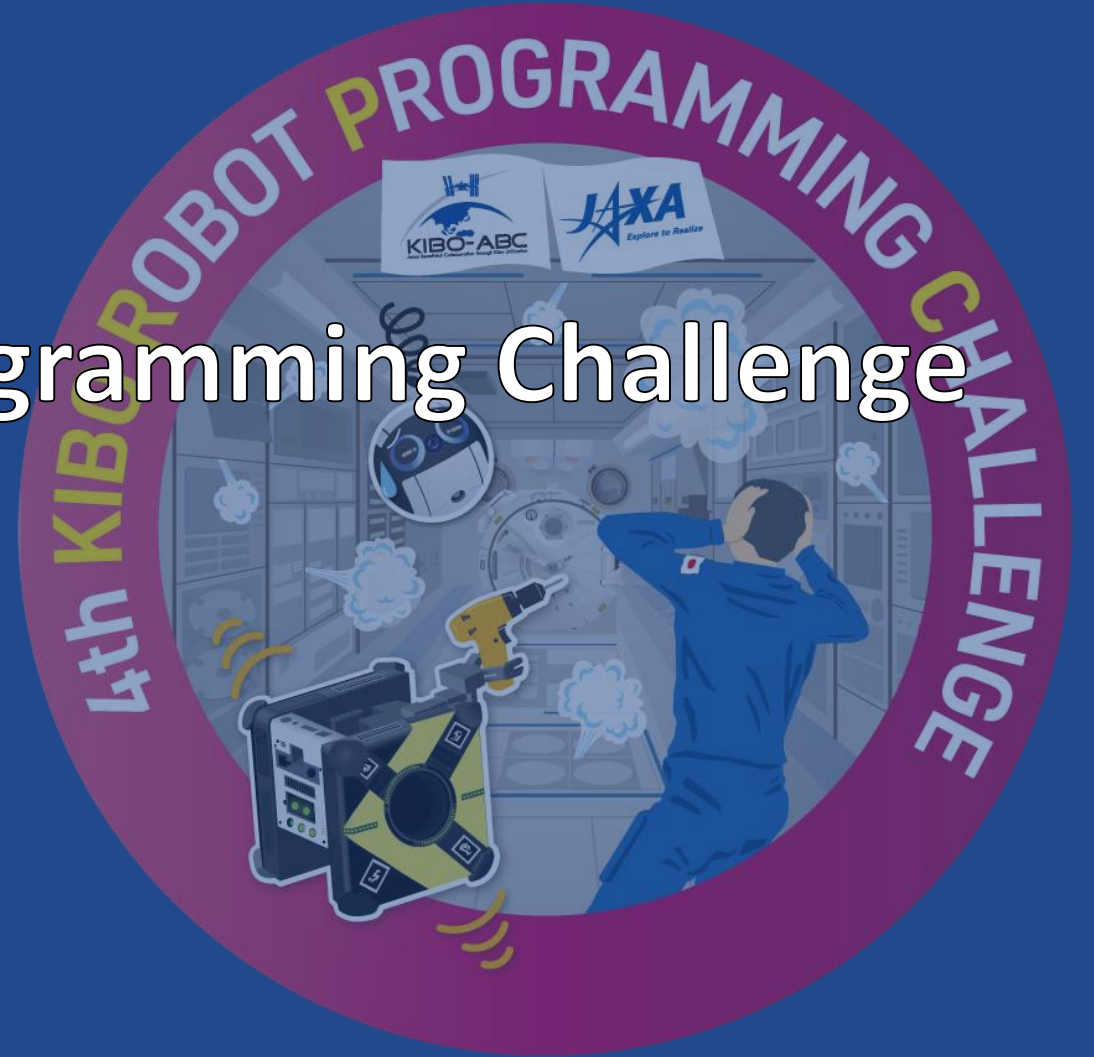


4th and 5th Kibo Robot Programming Challenge Overview

November 16th, 2023
Astrobee Working Group

Kibo-RPC secretariat
Nakata Yui (DigitalBlast, Inc.)



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 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.

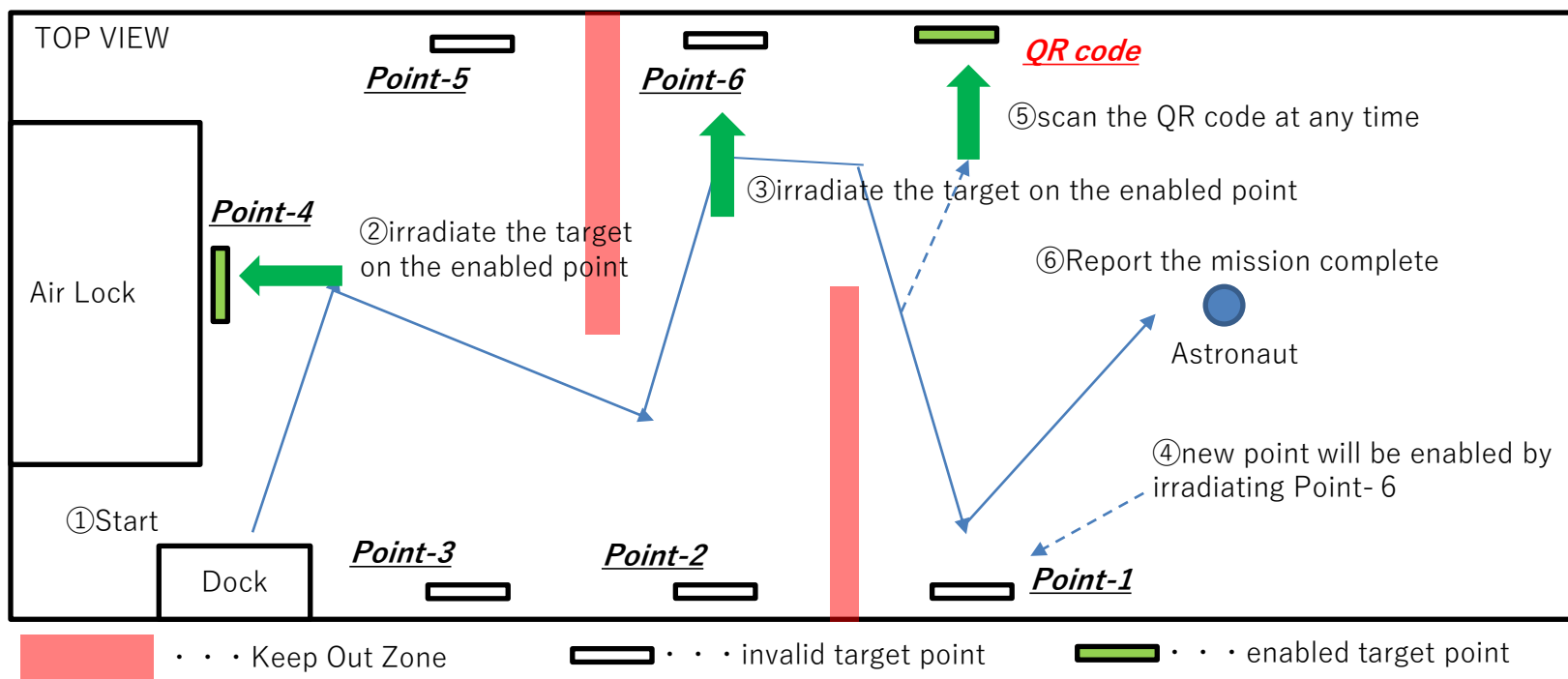
Repair the leakage points by laser irradiation of Astrobee!



※ 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

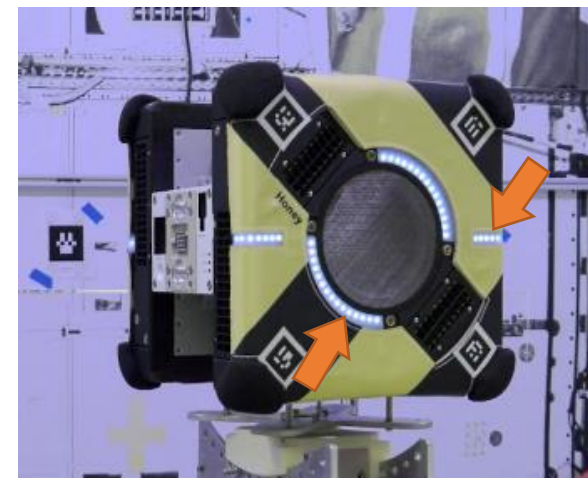


Mission Completion Report

- 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.)

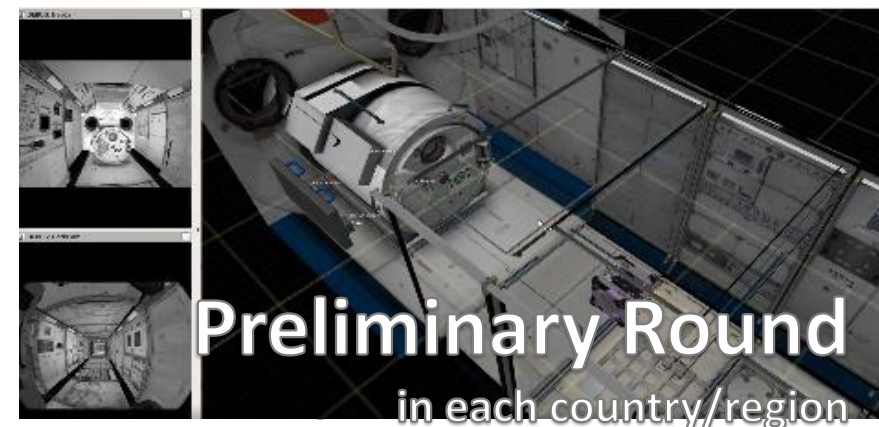
 - Based on the information obtained from the QR code, the appropriate signal light pattern is selected from a predetermined set of patterns.
 - If the information is **correct**:
 - While the **Signal Lights are illuminated**, the arm is extended to **release the sponge ball**.
 - The crew catches the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

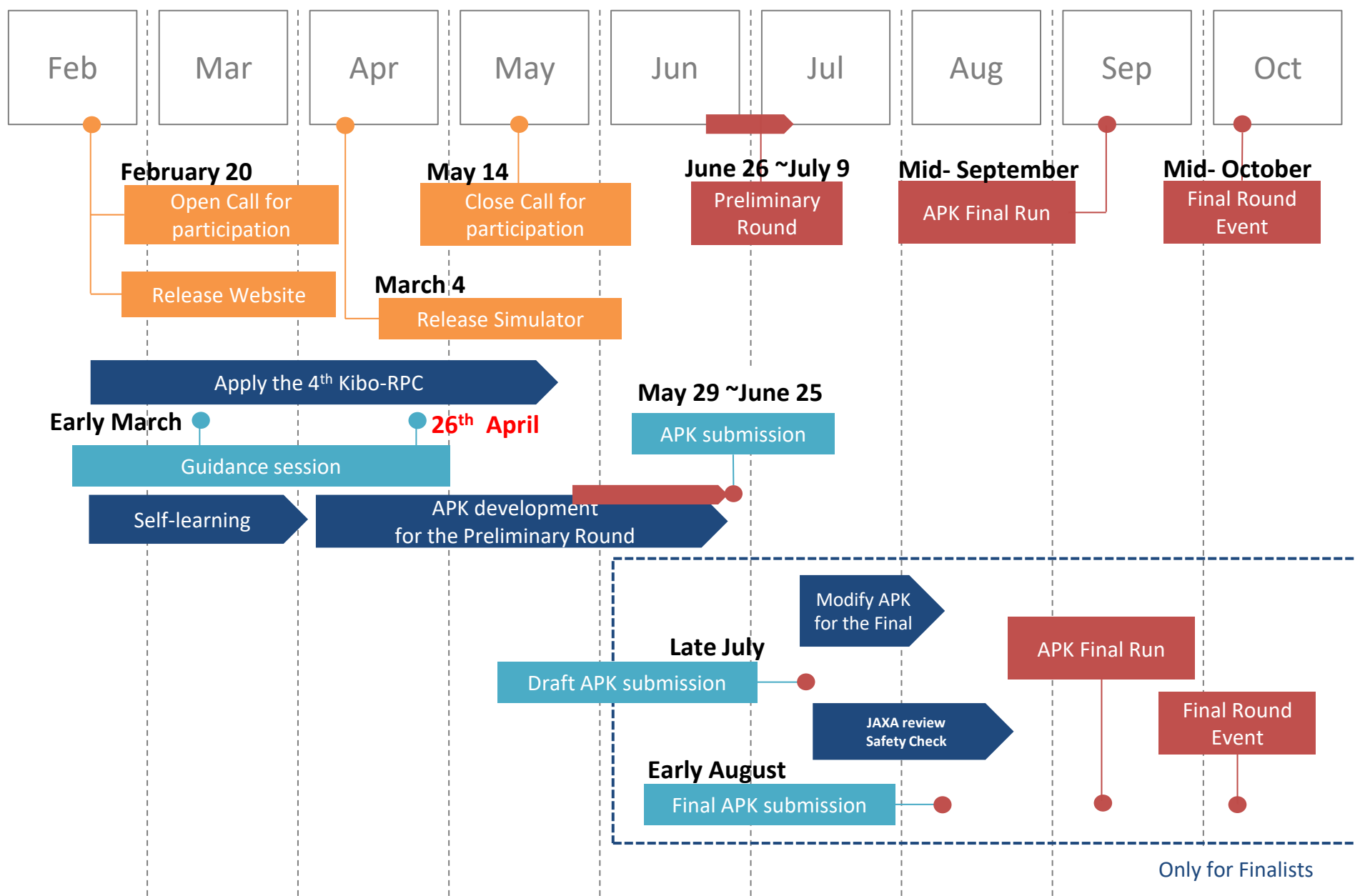


□ Final Round

- ✓ 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.



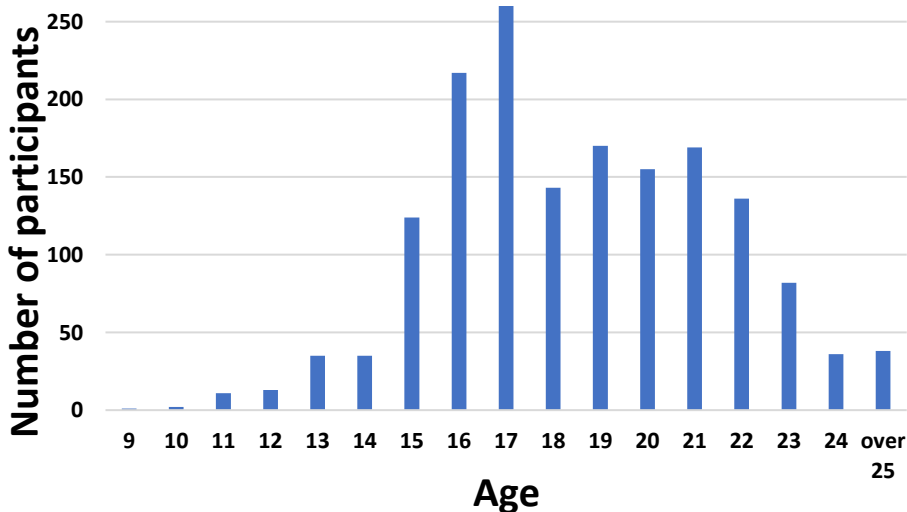
Schedule



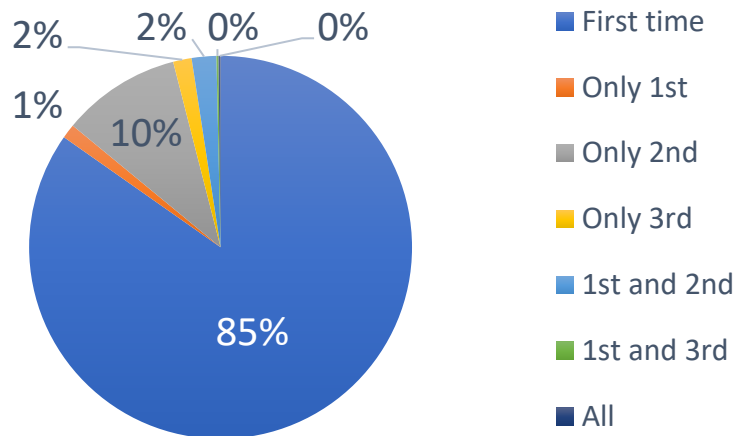
The 4th Kibo-RPC Participation

Total: **421** teams and **1685** participants

Country / Region	Teams	Participants	Country / Region	Teams	Participants
Australia	3	18	Taiwan	29	116
Bangladesh	76	299	Thailand	182	718
Japan	27	114	United Arab Emirates	9	37
Malaysia	12	54	Vietnam	1	4
Nepal	1	10	The United States	26	105
Singapore	6	23	UNOOSA	50	150



Participating Experience of past Kibo-RPC



The 4th Kibo-RPC Participation

Item	1st	2nd	3rd	4th
Team	313	286	347	421
Countries/ Regions	7	11	11+WWT	11+UNOOSA
Students	1,168	905	1,431	1,685
Finalist Teams	7	9	10	10

- ❑ In the 4th Kibo-RPC, the number of participants/teams reached an all-time high.
- ❑ **The United Nations Office for Outer Space Affairs (UNOOSA)** International Slot has been established, as a means to foster international expansion within the competition.
- ❑ In addition to participants from Kibo-RPC member countries/regions, students from **19 additional countries** have engaged in the competition through the UNOOSA International Slot.

4th Kibo-RPC Finalists that won the National Preliminary Round

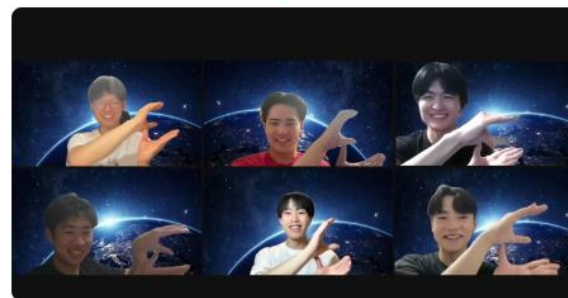
Team **Dream Rover**



Team **Team Paragon**



Team **Eager Hoper**



Team **Zetsubo**



Team **SST 1**



Team **Flying Unicorns**



Team **Galactic4**



Team **AUS-IEEE-RAS**



Team **Salcedo**



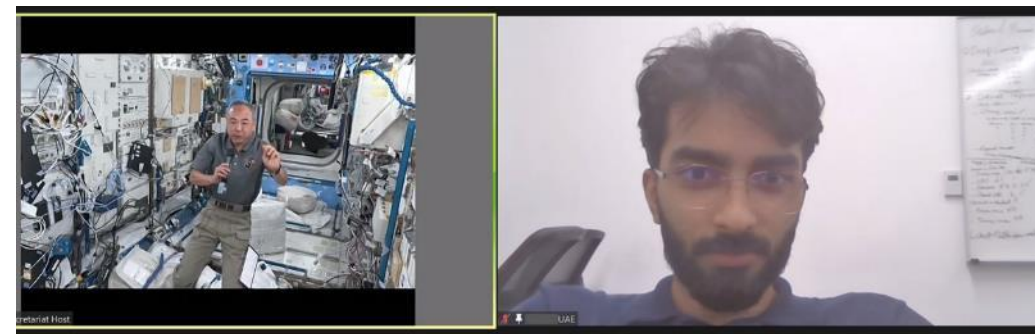
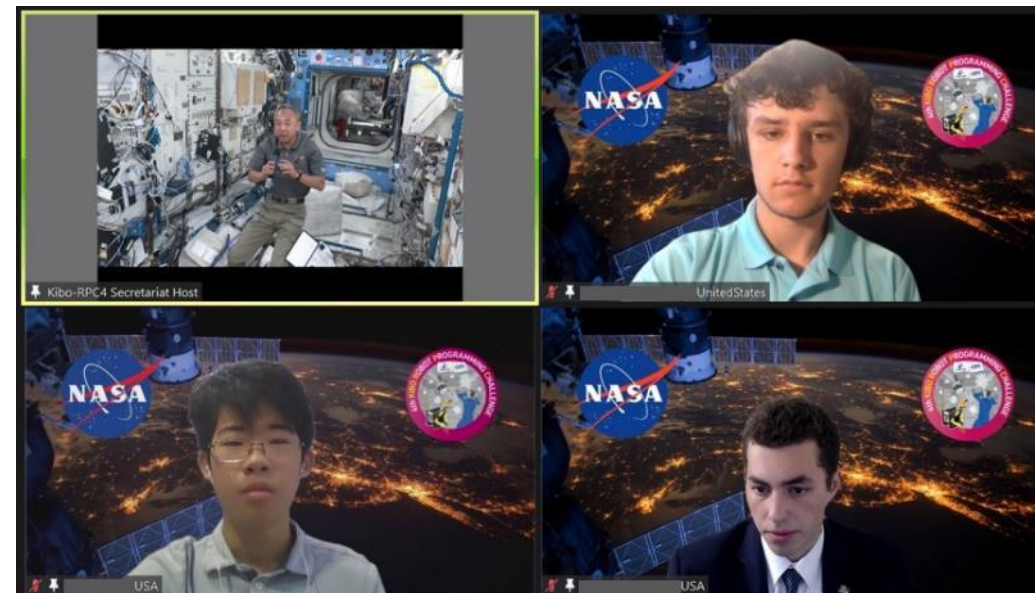
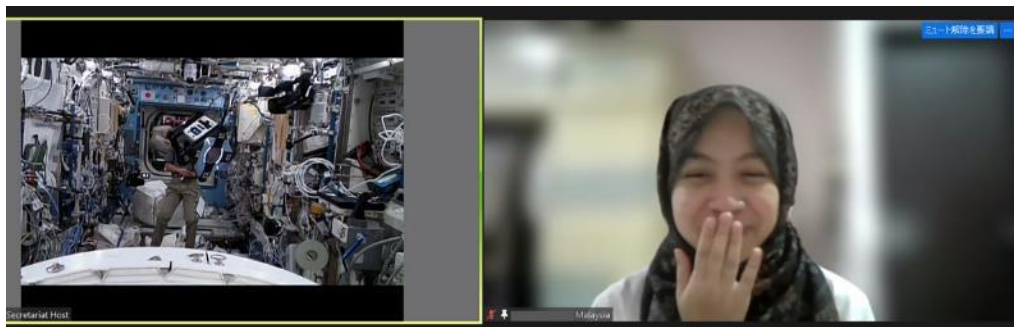
Team **ORION**



The 4th Kibo-RPC APK Final Run

On September 13, 2023, the finalists watched their run via Zoom.

All finalist's APK was performed successfully on the ISS!



The 4th Kibo-RPC Final Round Event

On October 21, 2023, the Final Round Event was conducted to announce the winner. It marked the first time the finalists had attended this event in person.

Country / Region	Final Round Event
Australia	Online
Bangladesh	Online
Japan	On-site
Malaysia	Online and On-site
Singapore	Online
Taiwan	On-site
Thailand	On-site
United Arab Emirates	Online
The United States	Online
UNOOSA	Online



The 4th Kibo-RPC Final Round Event

Date: October 21st, 2023

Final Round Event: 13:00 – 14:30 (JST)

Workshop: 15:00 – 16:30 (JST)

Agenda

Opening video

Introduction

Video message from ARC

Team introduction and run

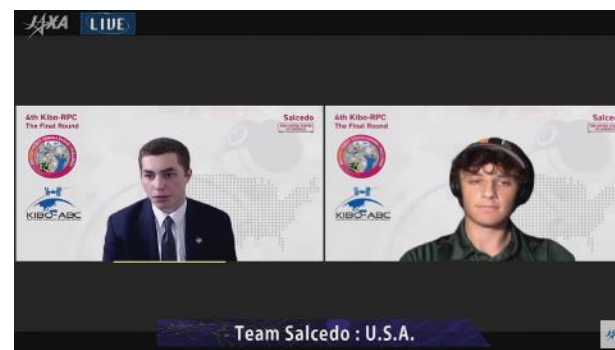
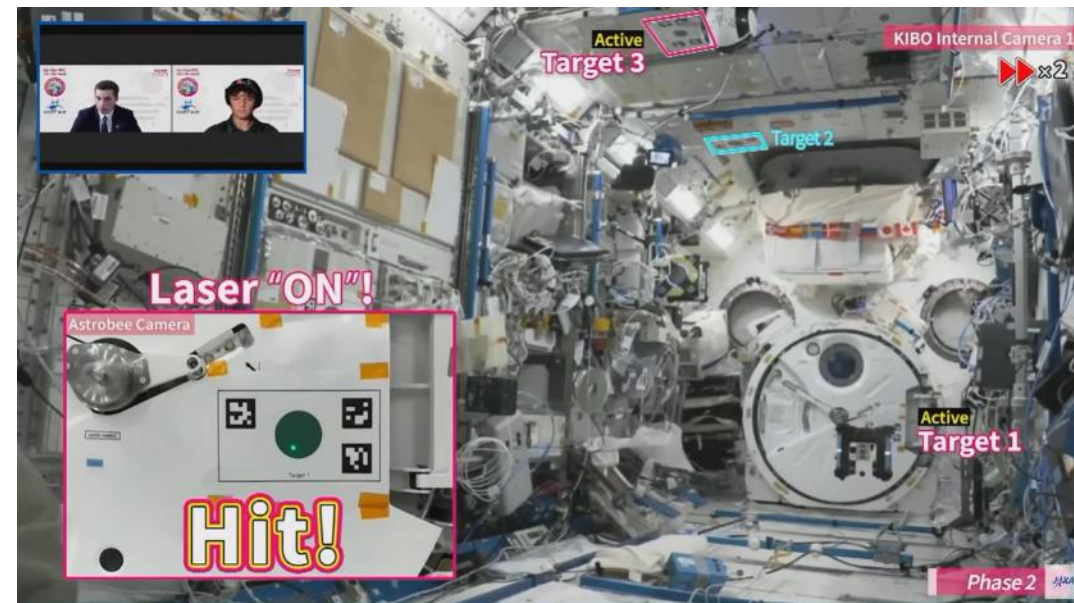
Award ceremony

Interview from the winner

Review from Prof. Nakasuka

Closing remarks video from JAXA astronaut Furukawa and UAE astronaut Al Neyadi

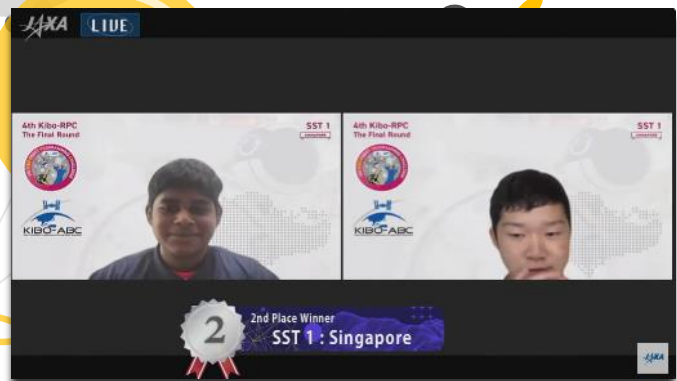
Closing



YouTube : <https://www.youtube.com/live/DBKVAojl0GQ?si=vZa0kXnCfSgSz71d>

The 4th Kibo-RPC Final Round Event

Congratulations!



2nd Place
(SST 1)























1st Place
(Flying Unicorns)



3rd Place
(Galactic4)

The 4th Kibo-RPC Final Round Event

The time limit is 5 minutes.

Country / Region	Team Name	Rank	Mission Completion Time	Number of Phases	Reaching the Goal	Reading QR	Laser Hit / Active Targets	Score
Taiwan	Flying Unicorns	1	4:56.5	5			4/7	110.77
Singapore	SST 1	2	3:36.6	3			2/4	98.54
Thailand	Galactic4	3	4:38.5	4			4/6	94.79
UNOOSA	ORION	4	4:51.1	4			4/6	91.99
Bangladesh	Team Paragon	5	4:14.1	3			1/4	70.20
UAE	AUS-IEEE-RAS	6	4:08.2	4			3/6	61.51
Malaysia	Zetsubo	7	3:53.5	2			1/3	24.77
Australia	Dream Rover	8	5:25.8	3			0/4	Time's up
Japan	Eager Hoper	8	5:17.4	4			3/6	Time's up
US	Team Salcedo	8	-:-	3			2/4	Time's up

The 4th Kibo-RPC Final Round Event

Date: October 21st, 2023

Final Round Event: 13:00 – 14:30 (JST)

Workshop: 15:00 – 16:30 (JST)

Agenda of Workshop

Lecture by SEC

Kibo-RPC 4th Final Round Source Code
Review Feedback

The student session

The comments from top teams
The things you ask other teams

Lecture by Prof. Nakasuka

Difference between the Real microgravity
environment and Simulation
Environments for programming

Lecture by JAXA

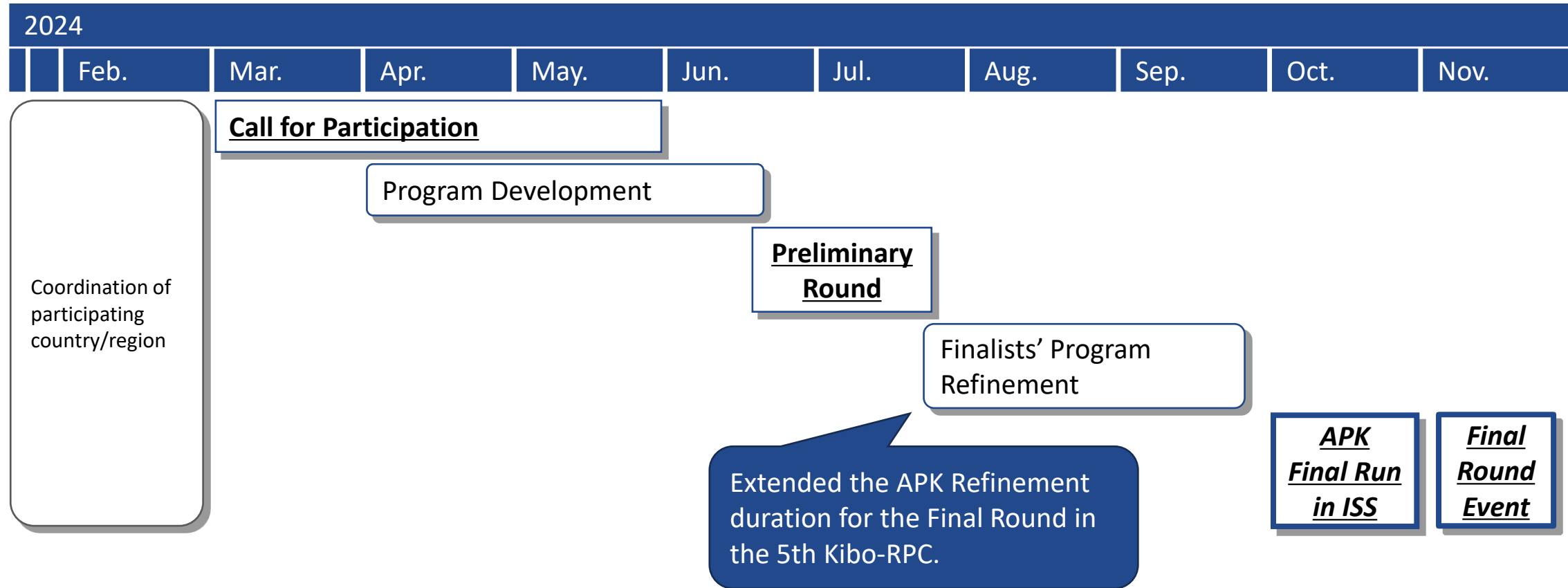
How to use Robots in Space

Lecture by JAXA astronaut Koichi Wakata

The Life and Work in Space + Q&A



The 5th Kibo-RPC Announcement



Overall schedule

- ✓ The event is scheduled to take place in 2024.
- ✓ The overall timeline closely follows that of the 4th Kibo-RPC.
 - Move Final Round backwards to allow more time for finalists' program refinement.

The 5th Kibo-RPC Announcement

□ New game rule

- ✓ JAXA is considering a new game rule using NASA's Astrobee.
- ✓ The game rules will be different from the previous rules.

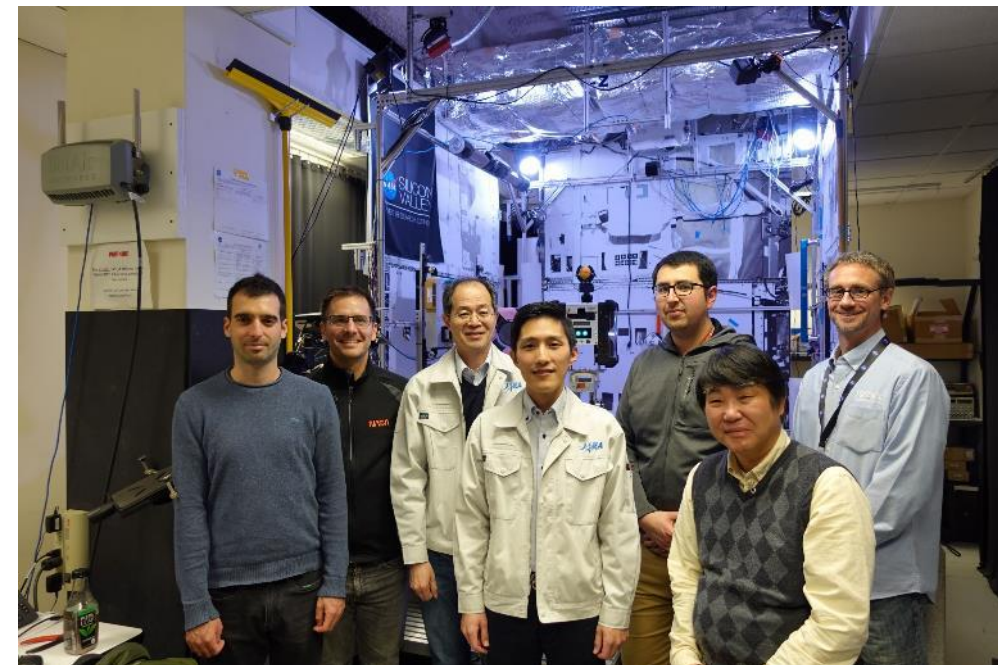
□ Int-Ball2

- ✓ JAXA's Int-Ball2 is now onboard.
- ✓ Int-Ball2 will be used to take video during competition.



Acknowledgement

- JAXA express our sincere appreciation to the Astrobee Facility Team at NASA Ames for their invaluable support and outstanding collaboration, particularly during the annual JAXA technical team visits to NASA Ames Research Center.
- Our heartfelt gratitude goes to the NASA Office of STEM Engagement for their dedicated efforts in facilitating interactions with students and contributing significantly to domestic events.



Thank you for listening!

