JAXA

1st Kibo Robot Programming Challenge
Preliminary Round Rulebook

Version 1.2 (Released Date: May 25th, 2020)

Japan Aerospace Exploration Agency (JAXA)

General Point of Contact: Z-KRPC@ml.jaxa.jp

List of Changes

All changes to paragraphs, tables, and figures in this document are shown below;

Release Date	Revision	Paragraph(s)	Rationale
March 30th, 2020	1.0	All	-
April 13th, 2020	1.1	3.2	Added APK submission method
May 25th, 2020	1.2	4.1	Corrected an omission in the description of time limit constraints.

Contents

1. Introduction

Let's challenge your program to be the champion of your country/region!

All participants must join a preliminary competition by a simulator to be selected a national representative. Refer to Guidebook Chapter 2 for Preliminary Round game content.

All teams will compete with other participants by your own programs developed before Preliminary Round using JAXA's simulation environment. Please refer to the Programming Manual for how to develop programs. This round will be based on common scoring factors and game rules across the countries/regions, and one winning team from each country/region will be selected and can proceed to the qualification round / final round. Since event cases varies from country/region to country/region, the details of information such as venues and schedules will be announced by each country's/region's POC. This Guidebook mentions only general Preliminary Round rules are described.

2. Common rules for Preliminary Round

Four common rules for Preliminary Round are mentioned.

2.1. Preliminary Round period

The Preliminary Round period means the period which Preliminary Round is carried out by all countries/regions. Information of Preliminary Round in each country is described in the Preliminary Round information on the ACTIVITY tab in the JAXA web page. Please contact your country's/region's POC for more information.

Note: 1. Participants will not be able to run web simulations from "Preliminary Round" tab. "Preliminary Trial" tab is always available.

2. Participants will not be able to see the Preliminary Round results until the Preliminary Round period is over.

3. Thailand will have Preliminary Selection before the Preliminary Round period. Participants should check the details with the Thailand POC and participate in the Preliminary Selection.

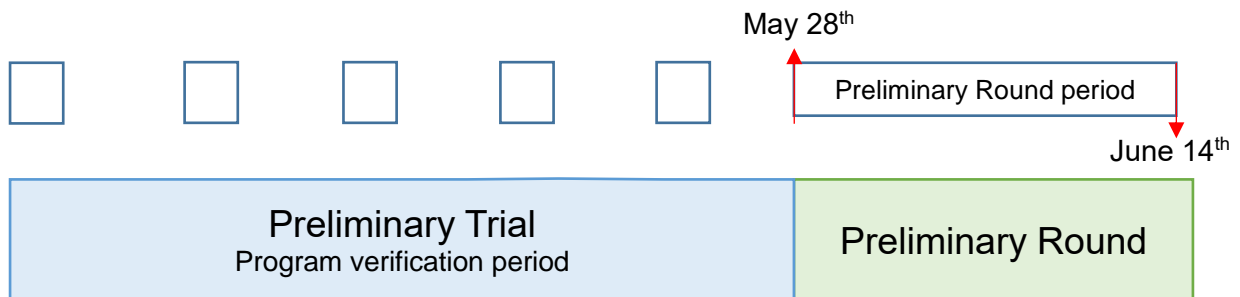Preliminary Round period: Thursday, May 28, 2020-Sunday, June 14, 2020 (JST)

Figure 2.1-1 Preliminary Round Period

2.2. Only one APK, only one challenge

Only one APK per team can be submitted in Preliminary Round. Therefore, participants must decide in advance which program you want to challenge with for Preliminary Round.

The APK can be challenged only once, no re-do, in order to keep fairness with any Preliminary Round styles in section 5. Therefore, it is important to pay enough attention to the selection of the program.

2.3. 10 automatic runs per APK

In Preliminary Round, 10 runs are automatically executed for one APK to keep the fairness against the random elements included in the simulation.

This method avoids the accidental results (good and bad results by happening) and ranked by the environmental and disturbance conditions. All participants can challenge in the same condition.
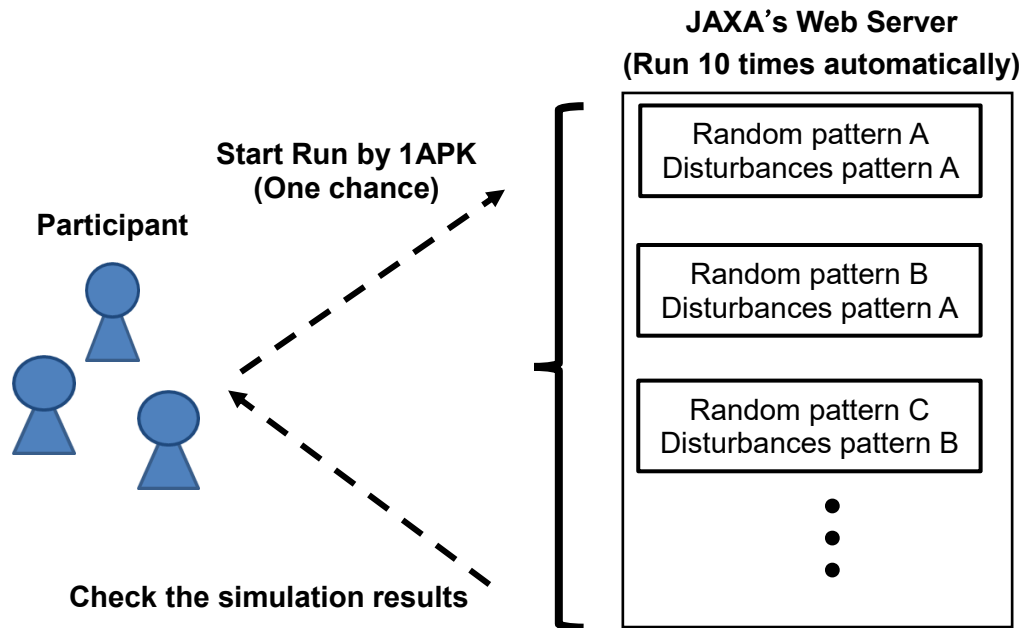

Figure 2.3-1 10 times run

2.4. Ranked by the worst result of 10 automatic runs

The ranking will be decided by the worst score in 10 runs.

Space missions are performed under very severe conditions, such that even one failure is not allowed to make, and that a malfunction cannot be recovered directly by human hands. This mission scenario is also an important mission that cannot be failed to help the astronaut's life at the ISS crisis, so it is necessary to complete the mission even with the worst result. Therefore, in order to evaluate programming that can perform well under any conditions, the ranking uses the worst result.

Detailed scoring criteria are provided in Section 4.3.

3. Joining Preliminary Round

3.1. How to participate in Preliminary Round

Participants must submit the APK for Preliminary Round by the date specified by each country's/region's POC. Please contact each country's/region's POC about the deadline.

3.2. Submission of Preliminary Round APK

Participants must create and submit a program for Preliminary Round in advance to participate in the Preliminary Round by the submission deadline set by your country POC.
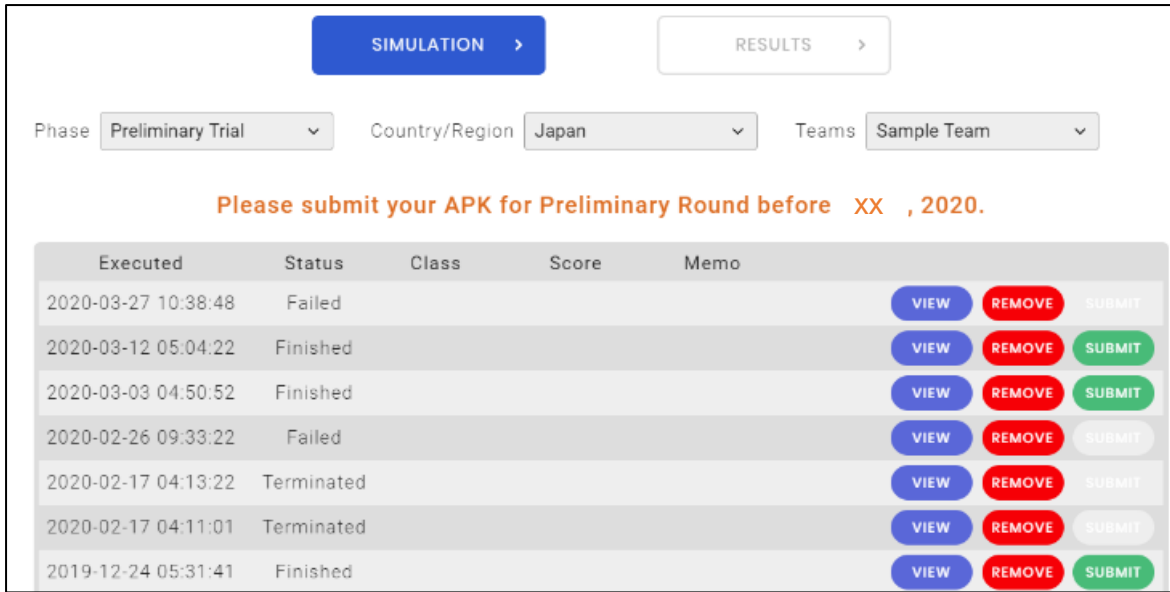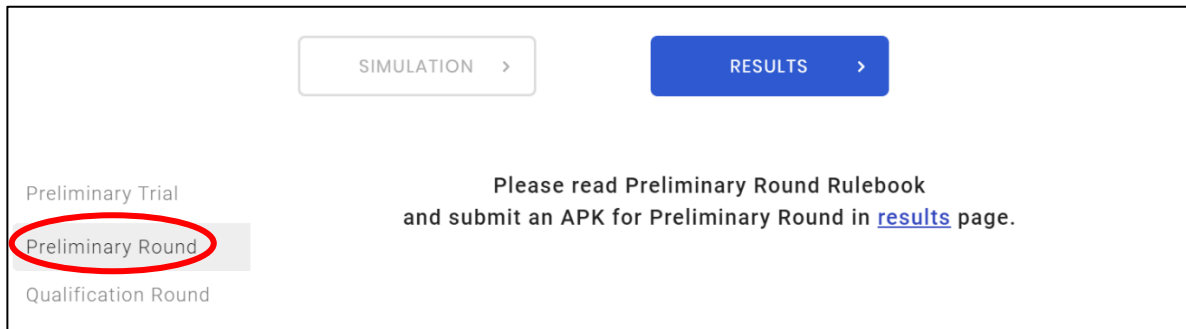

Figure 3.2-1   Preliminary Round

By the Preliminary Round period, the web simulation result screen will be changed as shown in Fig. 3.2-2. Before submitting your APK, you should evaluate the performance of your program using Preliminary Trial simulator. After that, select your best program from result list of "Preliminary Trial" on "RESULTS" screen, and press the "SUBMIT" button that is newly added and then the APK is submitted. Once press the "SUBMIT" button, it is changed to the "CANCEL" button. Therefore, you can resend the other APK by clicking the "CANCEL" button before the deadline set by each country/region.

Note: "SUBMIT" button can only be pressed when you subumit the APK that is "Finished" status in the "Preliminary trial". If you have only "Failed" APK, you

cannot participate in the Preliminary Round. Please make sure to create an APK that is "Finished" in the "Preliminary trial".
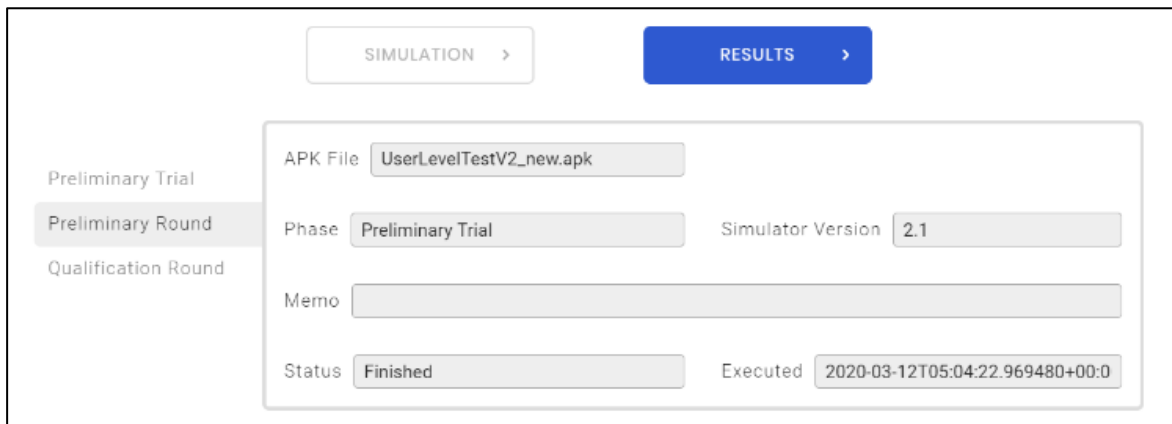

Figure 3.2-2 Preliminary Trial after change

The submitted APK can be confirmed from the "Preliminary Round" tab as shown in Figure 3.2-3. You can cancel the APK on RESULTS screen, but be careful about the submission deadline because you cannot press the "SUBMIT" and "CANCEL" button after that.

Figure 3.2-3 Preliminary Round

4. Settings and Conditions of Simulation

4.1. Game flow

All teams need to create a program such as following points to control NASA's Astrobee in JAXA's simulation environment.

1. Move Astrobee from the start position to P3 by using QR codes at P1-1 to P2-3 including information of the absolute coordinate system.

2. Move Astrobee to P3 based on information obtained at P1-1 to P2-3, and you will be able to find the "Target Point" that represents the air leak point with Astrobee's camera. Approach Astrobee the target from P3 and stop it at the appropriate distance from the target point using the target's AR tag.

3. Use an image processing algorithm to illuminate the center of the target point with Astrobee's laser pointer. It will be necessary to allow for the offset between Astrobee's camera and the laser pointer.

   * The time limit is 10 minutes for one run. If the program does not complete the mission within 10 minutes, the action after 10 minutes will not be reflected in the score.

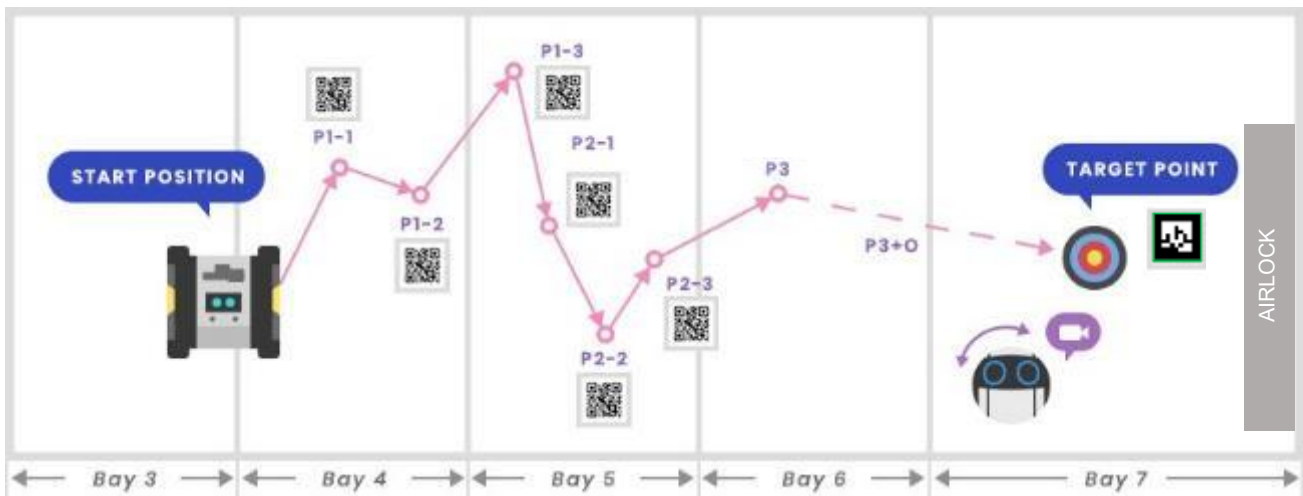   Make sure your program complete the mission within the time limit.

Figure 4.1-1 Game Outline of the Preliminary Round

Figure 4.1-2 Astrobee Simulator Server Sample Screenshots

4.2. Preconditions

Table 4.2 Preconditions of the Preliminary Round

#	Content
1	The starting position is fixed. The coordinates are; Position (x, y, z) = (10.95 -3.75 4.85) Orientation (x, y, z, w) = (0 0 0.707 -0.707) (Undock command is not needed.)
2	There is an AR tag near the target point. The position of the target point and an AR tag are varied randomly.
3	P3 is a fixed position around the target point (the camera can capture the AR tag there). QR codes at P1-1 to P2-3 provide information about P3.
4	About the positions of P1-1 to P1-3 and P2-1 to P2-3, please refer to 4.4 Object.
5	A Keep-Out Zone (KOZ)* that simulates an obstacle is set somewhere in the path from the start position to P3. This KOZ is given as a precondition. About the detail, please refer to 4.5 Keep-Out-Zone. * Astrobee cannot move into KOZ.

4.3. Scoring Factors

Table 4.3-1 Scoring Factors of the Preliminary Round

#	Factor	Detail
1	Arriving at transit point (P1-1 to P2-3)	You can get points by reading QR code information correctly at each transit point.
2	Finding the target point	You can get points by reading an AR tag ID correctly at each transit point.
3	Approaching the target point	You can get points by illuminating the target point with Astrobee's laser. The score change depending on the accuracy of the laser aiming to the target point.
4	Elapsed time	You are judged by the time used to complete the mission.

4.4. Ranking method

The results are categorized according to the degree of achievement of the mission (See Table 4.4-1) with the worst run score, and a team which marked the higher score in the same class ranks high.

Rank is given in order of class A > B > C > D > E (See Table 4.4-2).

Table 4.4-1 Classification by achievement

Class	A	B	C	D	E
Finding P1-1	○	○	○	△	✕
Finding P1-2	○	○	○	（1 to 5 QRs found）	
Finding P1-3	○	○	○		
Finding P2-1	○	○	○		
Finding P2-2	○	○	○		
Finding P2-3	○	○	○		
Move to P3	○	○	✕	-	-
Laser irradiation	○	✕	-	-	-

A： All missions are achieved. Found all the QR codes from P1-1 to P2-3, moved to P3 by finding AR tag, and irradiated the target with the laser within the time limit of 600 seconds.

It is ranked in the order of the points obtained by the scoring criteria. Score range is from 0 point to 100 point and it is calculated from accuracy of laser pointing and elapsed time. The laser accuracy and elapsed time are weighted in this criteria, respectively.

B： Found AR tag at P3 but laser irradiation failed. It is ranked in the order of the time until move to P3.

C： Found all the QR codes from P1-1 to P2-3.

It is ranked in the order of time until all P1-1 to P2-3 are found.

D： Found a part of QR codes from P1-1 to P2-3.

It is ranked by the number of QR codes you get.

When some team has the same number, it is ranked in order of time until finding QR code.

E： All missions are failed. Could not find QR code. No score.
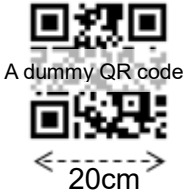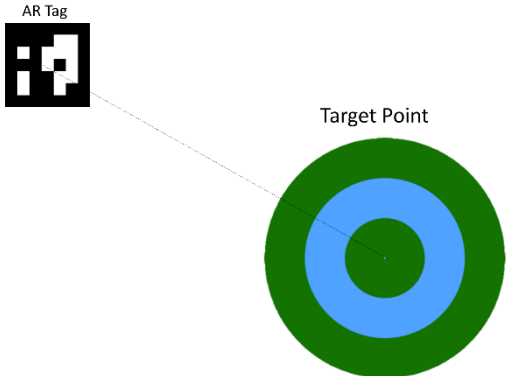
Table 4.4-2 Ranking and Class relation

Ranking	Team	Class	Score
1st	Team Q	A	80 pt
2nd	Team W	A	78 pt
3rd	Team E	A	66 pt
4th	Team R	A	32 pt
5th	Team T	B	6:14
6th	Team Y	B	7:30
7th	Team U	C	9:15
8th	Team I	D	4QRs 9:55
9th	Team O	D	4QRs 9:57
10th	Team H	D	3QRs 8:05
11th	Team X	D	1QRs 9:07
12th	Team P	E	-

※Classified by the worst run result. Therefore, even if 9 runs have completed the mission to the end, it is ranked by the worst run result when do not reach to the end within 10 minutes even once. In other words, the result of the runs that did not reach the end is the team's evaluation.

It is important to create a program that can accomplish missions under any random conditions.

4.5. Objects

Table 4.5-1 Objects of the Preliminary Round

#	Name of object	Method
1	QR code tag	The size of QR code tag is 20cm square. Information format is followings. Please create the program to move to P3 by quoting the values in [ ]. P1-1：pos_x, [P3 x coordinate]　(e.g. pos_x, 1.23) P1-2：pos_y, [P3 y coordinate]　(e.g. pos_y, 1.23) P1-3：pos_z, [P3 z coordinate]　(e.g. pos_z, 1.23) P2-1：qua_x, [P3 quaternion element x] (e.g. qua_x, 1.23) P2-2：qua_y, [P3 quaternion element y] (e.g. qua_y, 1.23) P2-3：qua_z, [P3 quaternion element z] (e.g. qua_z, 1.23) A dummy QR code 20cm Table 4.5-2 Position Information of QR code tags <table><tr><td>No.</td><td>Position (x, y, z)</td><td>Orientation (x, y, z, w)</td></tr><tr><td>P1-1</td><td>(11.5, -5.7, 4.5)</td><td>(0, 0, 0, 1)</td></tr><tr><td>P1-2</td><td>(11, -6, 5.55)</td><td>(0, -0.7071068, 0, 0.7071068)</td></tr><tr><td>P1-3</td><td>(11, -5.5, 4.33)</td><td>(0, 0.7071068, 0, 0.7071068)</td></tr><tr><td>P2-1</td><td>(10.30, -7.5, 4.7)</td><td>(0, 0, 1, 0)</td></tr><tr><td>P2-2</td><td>(11.5, -8, 5)</td><td>(0, 0, 0, 1)</td></tr><tr><td>P2-3</td><td>(11, -7.7, 5.55)</td><td>(0, -0.7071068, 0, 0.7071068)</td></tr></table>
2	Target Point	The size of AR tag is 5cm square -It is located 45° and 20cm upper left from target point. -"Aruco.DICT_5X5_250" is used as dictionary. The size of target point is 5cm radius. AR Tag Target Point Figure 4.5-1 Target point and AR code

4.6. Keep-In-Zone (KIZ) and Keep-Out-Zone (KOZ)

Keep-In-Zone (KIZ) is defined as the area where Astrobee can move around, and basically set along the walls of Kibo. It is a preset boundary in Astrobee and if the destination of the moving path of Astrobee is outside the KIZ, that is rejected. You need to design each moving path of Astrobee within the KIZ.

The Keep-Out-Zone (KOZ) are set inside the KIZ as a volumetric zone and used as some obstacles inside Kibo in the Kibo-RPC. You need to design each moving path of Astrobee to avoid the KOZ. (Refer to Figure 4.6-1, 4.6-2, 4.6-3 and Table 4.6-1)
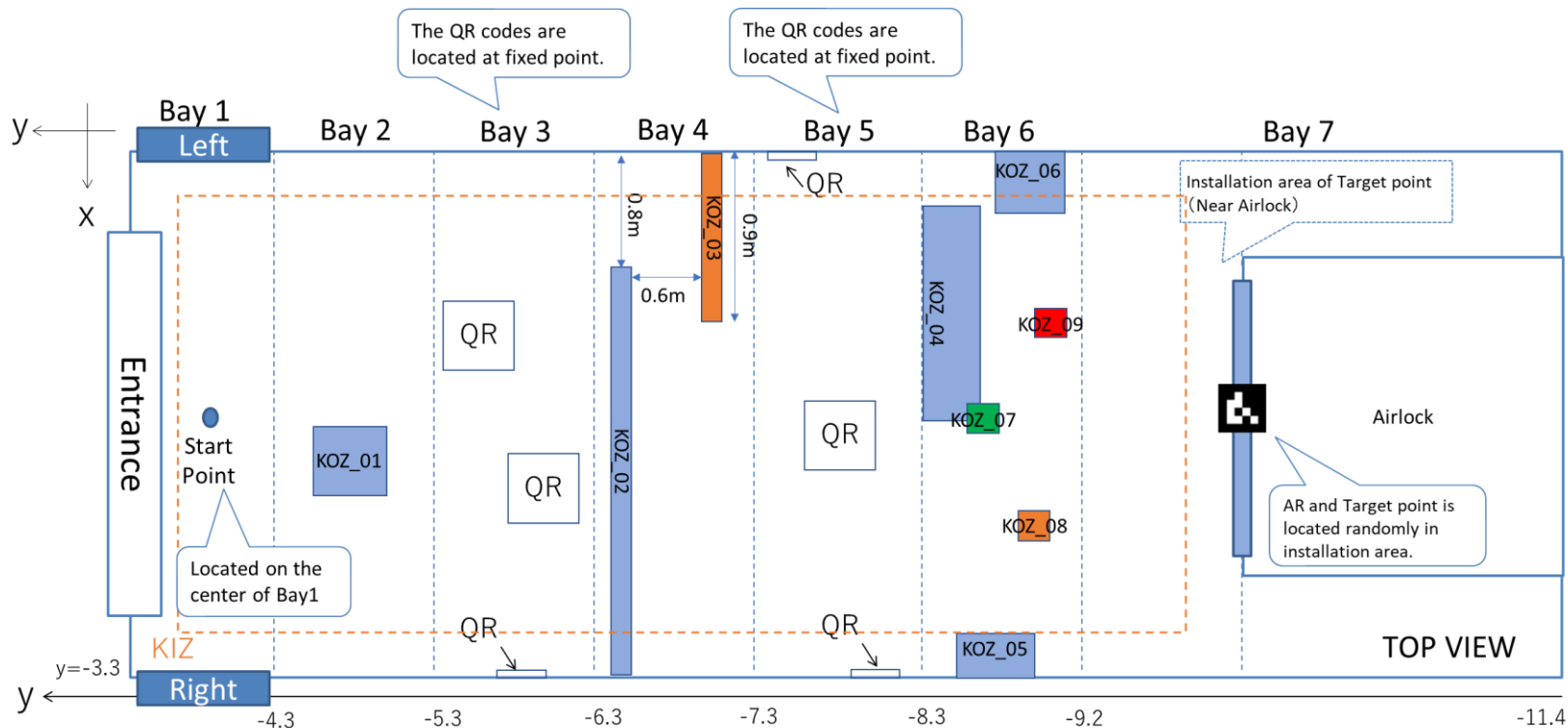
Figure 4.6-1 KIZ and KOZ of the Preliminary Round (Top View)
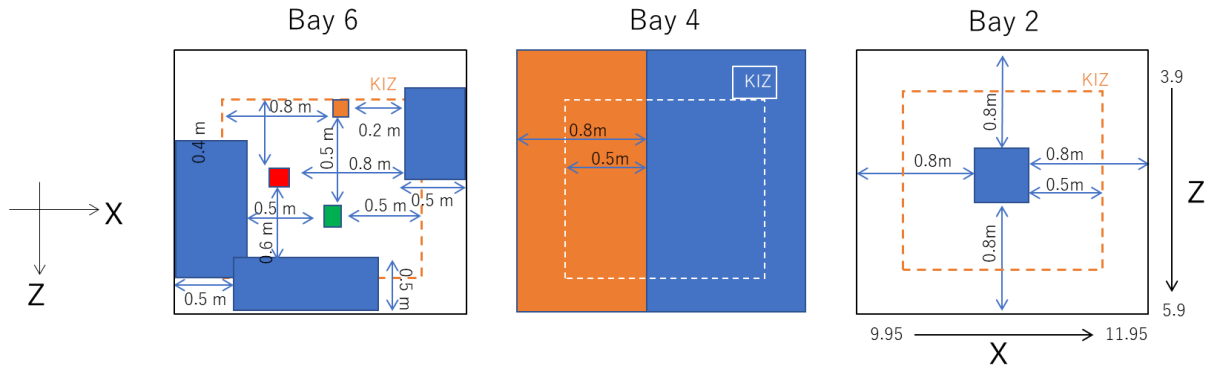
Bay 6   Bay 4   Bay 2

Figure 4.6-2 KIZ and KOZ of the Preliminary Round (Sectional View)

Table 4.5-1 Installed Coordinate of Obstacles

#		x_min	y_min	z_min	x_max	y_max	z_max
KOZ_	01	10.75	-4.9	4.8	10.95	-4.7	5.0
	02	10.75	-6.5	3.9	11.95	-6.4	5.9
	03	9.95	-7.2	3.9	10.85	-7.1	5.9
	04	10.10	-8.6	5.4	11.1	-8.3	5.9
	05	11.45	-9.0	4.1	11.95	-8.5	5.1
	06	9.95	-9.1	4.6	10.45	-8.6	5.6
	07	10.95	-8.4	4.9	11.15	-8.2	5.1
	08	11.05	-8.9	4.2	11.25	-8.7	4.4
	09	10.45	-9.1	4.6	10.65	-8.9	4.8
KIZ		10.25	-9.75	4.2	11.65	-3	5.6

*The origin of the coordinate axis is set outside of Kibo

$x_{min}, y_{min}, z_{min}$

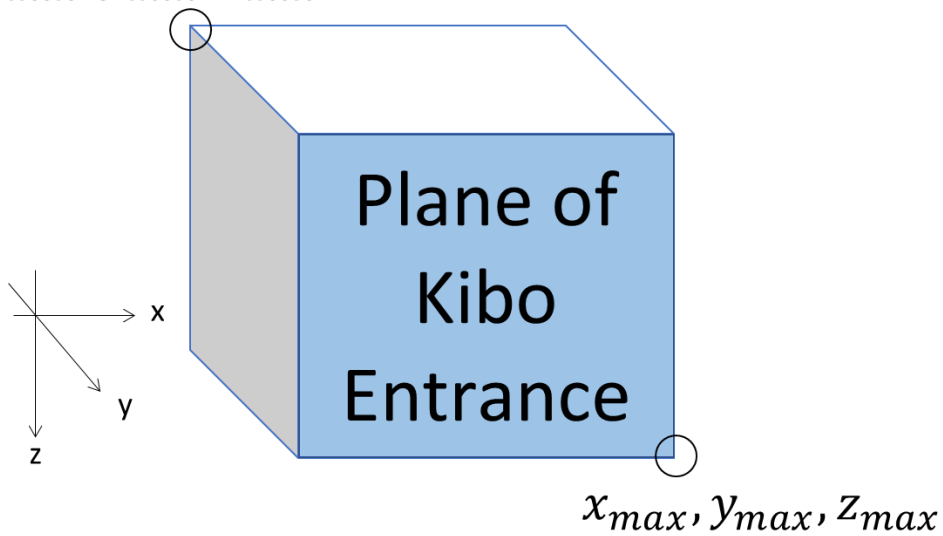Plane of Kibo Entrance

$x_{max}, y_{max}, z_{max}$

Figure 4.6-3 Definition of the coordinates

5. Event methodology

This section explains three typical Preliminary Round styles which are carried out in each country/region. Please confirm how your country/region will hold Preliminary Round event on the ACTIVITY tab on the JAXA web page, or contact your country's/region's POC.

5.1. Real Event

Real Event means the Preliminary Round event is held at a venue in your country /region. Participants must submit the APK on the web by the specified date which your country's/region's POC decided, and go to the venue on the day. However, if it is difficult to go to the venue, each team's leader should talk to your country's/region's POC and participate in an alternative way (typically through Social Media). Figure 5.1-1 shows the general flow.
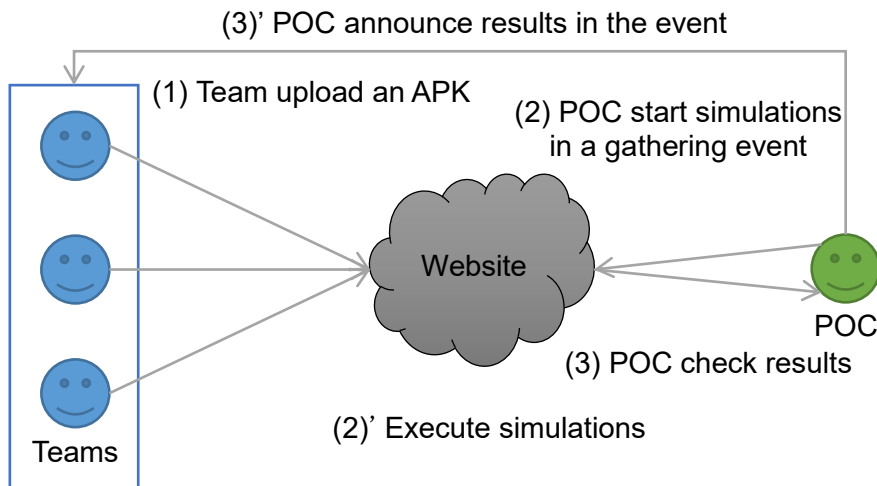

Figure 5.1-1 Real Event flow

5.2. Virtual Event

Virtual Event means the participants take part in the Preliminary Round through Social Media. Therefore, participants can participate from your school and home. The basic Preliminary Round procedure is the same as in section 5.1. Participants must submit the APK on the web by the specified date which your country's/region's POC decided.

5.3. E-mail Notification

E-mail Notification is a method that done without gathering with other participants, and the result is notified by e-mail from your country's/region's POC later. Therefore, participants do not need to participate in the Preliminary Round on a particular day. However, as in 5.1 and 5.2, participants must submit the APK on the web by the specified date which your country's/region's POC decided

<u>*Please confirm with the POC in each country/region
which style they will carry out.</u>