→ EUROPEAN ASTRO PI CHALLENGE 2019/20 MISSION SPACE LAB GUIDELINES

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→ INTRODUCTION

The European Astro Pi Challenge is an ESA Education project run in collaboration with the Raspberry Pi Foundation. It offers students and young people the amazing opportunity to conduct scientific investigations in space by writing computer programs that run on Raspberry Pi computers aboard the International Space Station (ISS).

The Astro Pi Challenge is divided into two separate missions featuring different levels of complexity: Mission Zero and Mission Space Lab. This document is a guide to participate in Mission Space Lab.

Mission Space Lab offers participants the chance to have their scientific experiments run on the ISS. The challenge is to design and program an experiment to be run on an Astro Pi computer. The best experiments will be deployed to the ISS, and teams will have the opportunity to analyse and report on the results. The teams that write the best reports will be selected as the Astro Pi Mission Space Lab winners!

In the first section of this document, you will find an overview of the challenge structure, and rules for entering. The other sections will take you through each phase of the challenge, with useful resources and tools you can use along the way.

→ OVERVIEW

To participate in Mission Space Lab, teams will have to come up with an idea for an experiment that fits one of the following two themes:

→ THEME A - LIFE IN SPACE

Teams that choose to investigate 'Life in space' will use the Astro Pi computer called Ed to investigate life inside the Columbus module of the ISS.

→ THEME B - LIFE ON EARTH

Teams that choose to investigate 'Life on Earth' will use the Astro Pi computer called Izzy, including its sensors and its near-infrared camera facing out of an ISS window towards Earth, to investigate life on the planet's surface.

Mission Space Lab consists of four phases:

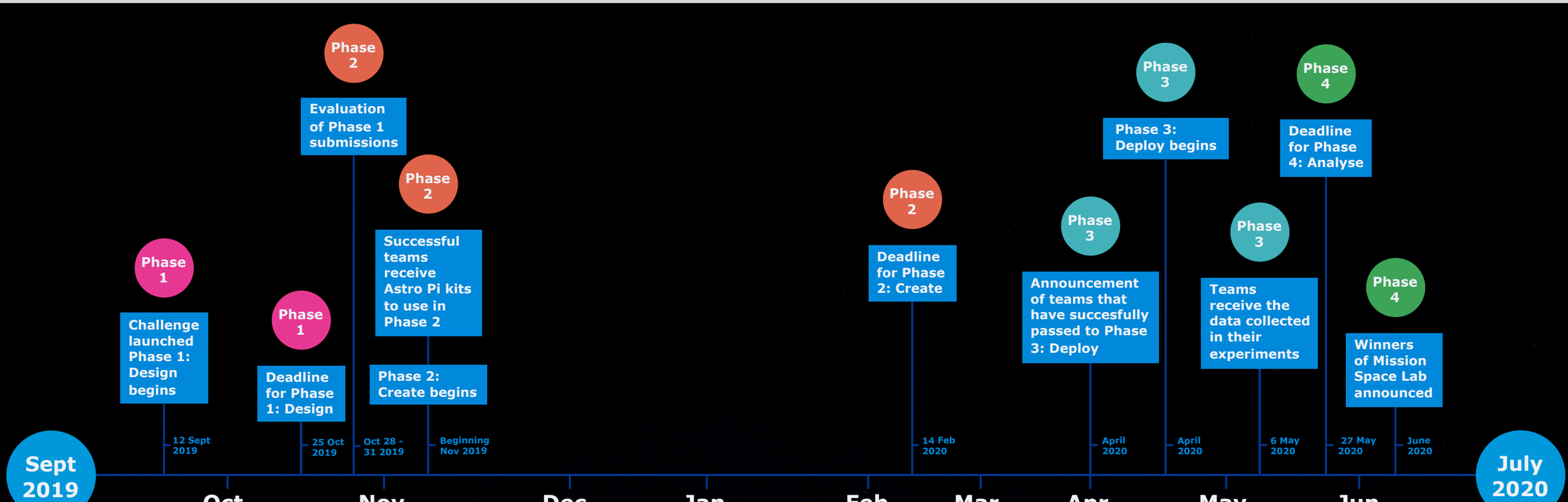
Phase 1 — **Design**
Come up with an idea for an experiment.

Phase 2 — **Create**
Write the program for your experiment and test it on Earth.

Phase 3 — **Deploy**
Your program is deployed on the ISS.

Phase 4 — **Analyse**
Use the data from your experiment to prepare your report.

→ OVERVIEW


Phase 1
Challenge launched Phase 1: Design begins
12 Sept 2019
Phase 1
Deadline for Phase 1: Design
25 Oct 2019
Phase 2
Evaluation of Phase 1 submissions
Oct 28 - 31 2019
Phase 2
Successful teams receive Astro Pi kits to use in Phase 2
Phase 2: Create begins
Beginning Nov 2019
Phase 2
Deadline for Phase 2: Create
14 Feb 2020
Phase 3
Announcement of teams that have succesfully passed to Phase 3: Deploy
April 2020
Phase 3
Phase 3: Deploy begins
April 2020
Phase 3
Teams receive the data collected in their experiments
6 May 2020
Phase 4
Deadline for Phase 4: Analyse
27 May 2020
Phase 4
Winners of Mission Space Lab announced
June 2020
Sept 2019
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
July 2020

→ CHALLENGE OVERVIEW

Phase 1

Design
(12 September – 25 October 2019)
In this phase, you just need an idea for an experiment! You don't need to do any coding yet, but you should think about how you might write the program for your experiment to make sure you don't set yourself an unachievable goal. Teams have until 25 October 2019 to register and submit their idea on the Astro Pi website.
We will notify the selected teams of their acceptance to Phase 2 by the beginning of November 2019.

Phase 2

Create
(Beginning of November – 14 February 2020)
In Phase 2, which will take place between beginning of November 2019 and 14 February 2020, selected teams will design and write the computer program necessary to perform the experiment they suggested in Phase 1.

Astronauts are always very busy, so the Phase 2 experiments will be run on the ISS Astro Pis as part of an automated deployment schedule. Therefore your program needs to meet some simple requirements so that it can be controlled automatically. Any programs that do not meet these requirements will not progress to Phase 3.

Teams selected to participate in Phase 2 of the challenge will receive an ESA-branded Astro Pi kit directly to their school or club. The kit contains the core equipment necessary for you to test your program; you will need to provide your own monitor, USB keyboard, and USB mouse.

The deadline for submissions (via the Astro Pi website) is 14 February 2020.

Phase 3

Deploy
(April 2020)
In this phase, the best experiments will be selected to receive 'flight status', and we will notify the teams that created these on 2 April 2020. The selected entries will be uplinked to the ISS and deployed on the Astro Pi computers. The programs will run on the ISS in April 2020 (depending on ISS operational constraints). Then the experimental data collected in orbit will be downlinked and distributed to the participating teams.

Phase 4

Analyse
(6 May – 27 May 2020)
We challenge all teams that have made it this far to analyse their data collected on the ISS and submit a short final report about the results of their experiment. We provide a report template for this.

Only teams that submit their final report will receive the official Astro Pi Challenge participation certificate. The teams that submit the best reports will be announced as Mission Space Lab winners, and they'll receive special winners' certificates.

The deadline to submit your final report is **27 May 2020**.

→ RULES FOR PARTICIPATION

To take part, teams must:

- Be made up of students/young people who each are no older than 19 years (recommended age range: 11–19)
- Have at least two and at most six students/young people as members
- Be supervised by a teacher, mentor, or educator, who will be the point of contact with the Astro Pi team
- Be made up of at least 50% team members who are citizens of an ESA Member State[1] or of Slovenia, Canada, or Malta

In addition, **each team member** must be at least one of the following:

- Enrolled full-time in a primary or secondary school located in an ESA Member State[1] or in Slovenia, Canada, or Malta
- Home-schooled (certified by the National Ministry of Education or delegated authority in an ESA Member State or in Slovenia, Canada, or Malta)
- A member of a club or after-school group, such as Code Club, CoderDojo, or Scouts located in an ESA member State or in Slovenia, Canada, or Malta

One teacher/mentor may supervise a maximum of five teams per year and will only receive one Astro Pi kit. If you are determined to co-mentor more than five teams, you need to find another teacher or mentor who can be the main point of contact and have that person apply with the extra teams!

There is no limit to the number of teams a school or club can enter. Each team can only submit one entry, and each student can only be part of one team.

All the submissions must be in English.

[1] **ESA Member States in 2019:**
Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, United Kingdom.

ESA will also accept entries from primary or secondary schools located outside an ESA Member State only if such schools are officially authorised and/or certified by the official Education authorities of an ESA Member State (for instance, French school outside Europe officially recognised by the French Ministry of Education or delegated authority).

Phase 1

→ DESIGN
12 SEPTEMBER – 25 OCTOBER

Phase 1 is all about your team coming up with an idea for an experiment you want to run on the Astro Pis aboard the ISS.

To do this, you will need to do the following:

1 **Organise your team**
As mentioned in the requirements section above, a team must consist of two to six students or young people, aged 19 years or younger, and half the team must be citizens of an eligible country.

Each team needs a teacher or mentor. This person will support the team during the challenge, and will be the main point of contact for us.

2 **Choose your theme**
There are two Mission Space Lab themes you can choose between, depending on what you would like your experiment to investigate:

Theme A – Life in space
An experiment in this theme will use the Astro Pi called Ed to investigate life inside the Columbus module. If you choose this theme, you will need to submit an experiment idea that makes use of Astro Pi Ed's LED matrix and at least one of its sensors, which include a visible-light camera. Note that the Astro Pi Ed will be deployed within the Columbus Module, and that you may use its camera only as a sensor and not to take photos or record videos.

Theme B – Life on Earth
An experiment in this theme will investigate life on the planet's surface using the Astro Pi called Izzy, including its sensors and its near-infrared camera facing out of a window in an ISS module pointing at Earth. If you choose this theme, you will need to submit an experiment idea that makes use of **Astro Pi Izzy's near-infrared camera (with a blue optical filter);** use of sensors is optional. Note that Astro Pi Izzy will be deployed in front of an Earth-facing window on the ISS, for example inside Node 2.

3 Design your experiment together

A. Preparation

i. Essential: Phase 1 checklist
It is crucial that your team understands the limitations of the Astro Pi hardware and what you're not allowed to do in your experiment. Your idea must fulfil the criteria in the following checklist, otherwise **your idea may be disqualified**.

→ EXPERIMENT IDEA CHECKLIST

- Your experiment can't rely on astronaut interaction. We can't be sure when an astronaut will be around the Astro Pis, and they have their own working schedule!
- Your experiment shouldn't be a game, but a scientific experiment!
- Real-time communication with the Astro Pis on the ISS is not possible, because we don't have a radio communication module to be able to 'give instructions' from Earth!
- Don't expect your experiment to run at a specific date and time. We can't predict accurately when each experiment will run!

Only for 'Life on Earth' experiments:

- Don't base your experiment on analysing the Earth's temperature profile: that's not possible with the Astro Pi hardware. The near-infrared camera is not a thermal imaging camera!
- Don't base your experiment on night-time photography. Most teams that have attempted this in the past ended up with entirely black images that couldn't be analysed.
- Don't expect to photograph or film a specific event or location of your choice. We don't know precisely where the ISS will be when your experiment runs, or whether a specific target on the ground will be visible on its flight path.
- It's OK if you want to photograph specific types of targets like lakes or forests, but make sure to program the experiment with as many similar targets as possible to maximise the chance that at least a few of them will be captured when your program runs.
- The detail level of the camera is about 161 metres on ground per pixel (assuming the ISS is at 400 km altitude), so don't expect to be able to see features like cars, roads, or buildings.
- Ensure you understand the ISS orbit. The ISS covers everywhere between 51.6 degrees latitude north of the equator and 51.6 degrees south of it. This means the ISS will never fly over places like Greenland, Siberia, or Antarctica. It is also unlikely that you will see the Aurora Borealis, because it occurs closer to the poles than these latitudes.

Only for 'Life in Space' experiments:

- Storing pictures or recording video is not allowed.

B. Brainstorm
This step is all about coming up with experiment ideas within your chosen theme. You can do this in any way you like. This is our suggestion for a brainstorming session:

i. Start by writing your ideas down on sticky notes, one idea per note, and sticking the notes to a board or wall. The ideas don't have to be fully formed research questions, so you can write down topics or things that inspire you. Make sure each team member adds some ideas.

ii. Once everyone has had an input, it's time to group the ideas according to themes or categories: sort the sticky notes to cluster similar ones together. While you do this, talk through the ideas as a team. Once you've sorted everything, you may wish to vote on which idea your team wants to pursue: have each team member place an X on their top three sticky notes.

iii. You should end up with one or two ideas that have received the most votes. Now it's time to do some research! To settle on your final experiment idea, spend a short amount of time researching your topics and also checking the hardware and Phase 2 resources listed in the next section. You might need to revise your idea a little, or maybe combine several things in one experiment.

4 **Tell us about your idea**
Head to the **Mission Space Lab web page** to submit your experiment idea. You will need to give us some details about the people in your team, and answer these two questions:

A. What is your experiment idea?

B. How will you use the Astro Pi computers to perform your experiment?

Your answers to these questions will help us assess your experiment for its feasibility, scientific value, and creativity.

You will also need to decide on a unique team name. This name must have eight or fewer characters and contain no spaces.

5 **Wait for our confirmation**
We will notify all teams about whether their experiment idea has been accepted for the next phase by the beginning of November.

Phase 2

→ CREATE

BEGINNING OF NOVEMBER – 14 FEBRUARY

In Phase 2, your team will write the program for the experiment you have proposed, and then test and submit it. These are the steps involved:

1 **Be accepted to Phase 2**
You will receive an email confirming your acceptance to Phase 2 of the challenge by the beginning of November.

2 **Receive your kit**
We will send an Astro Pi kit for your school or club to the address you provided in your Phase 1 submission. This kit contains the same hardware that is included in the Astro Pi computers aboard the ISS (apart from the special space-hardened case).

3 **Create your experiment: program checklist**
Read our comprehensive **Mission Space Lab Phase 2 guide** for information on assembling your kit, writing your program, and then testing your program. The guide also includes essential information on what is and isn't possible with the Astro Pi hardware and software. You can also have a look at **our resources** that go into more detail about the Astro Pi hardware and using it to write the program for your experiment.

→ PROGRAM CHECKLIST: Your program must:

- Be written using only the Python programming language
- Use the Sense HAT LED matrix
- Use at least one Sense HAT sensor or the Camera Module
- Use only the Python modules available on the Flight OS
- Save results for you to analyse later
- Not exceed 3GB of storage space for the results
- Not open a socket or attempt any networking
- Not run any Linux shell commands
- Not contain any pre-compiled code or obfuscated code
- Not use multithreading
- Not contain any form of profanity
- Not depend on human interaction, such as a key press, to run the experiment

Resources for this phase: rpf.io/ap-msl-guide

→ PROGRAM CHECKLIST: Things to remember

- Programs are not permitted to save photo or video files from within the ISS (applies to 'Life in Space' theme only).
- Programs should record data in log files as outlined in the coding requirements. Files should not be opened in other areas of the SD card directory structure.
- Programs should not attempt to open a network connection or to communicate across a network interface.
- Programs should not contain obfuscated code.
- Programs should not attempt to spawn other programs or to start, or interfere with, system processes.
- Programs should run for a maximum of three hours and terminate cleanly.

Programs that don't respect this checklist may be disqualified.

4 **Submit your program**

To submit your program, head to the **Astro Pi website.** You will need to:

A. Upload your program

B. Answer the following:

i. What are the main objectives of your experiment?

ii. Describe how you will achieve these objectives.

iii. What do you think the results of your experiment will be?

iv. Please estimate how much storage space (in megabytes) your experimental results will use on the Astro Pi computer.

Phase 3

→ DEPLOY APRIL 2020

Once you have submitted your program, it will be judged by our expert panel. They will be assessing your program according to its:

- **Scientific value**
  - Is your experiment investigating a scientific concept or principle?
- **Program readability and quality**
  - Is your program easily understandable?
  - Is it using comments and/or docstrings?
  - Is it structured well, and does it include rigorous error checking?
  - Is re-used code from other sources/authors correctly attributed?
- **Feasibility of the experiment in the ISS environment**
  - Can your experiment run according to the environment and hardware limitations aboard the ISS?
  - Is your experiment likely to produce meaningful data?
- **Clarity and comprehensiveness**
  - Are your experiment's objectives clear based on the program you have written and the answers you have submitted?
  - Could the experiment be easily reproduced?
  - Does it follow the guidance provided in the Phase 2 guide?

If your program passes the expert panel of judges, we will test it on ground to ensure that it runs without errors and that it doesn't violate any of the security rules.

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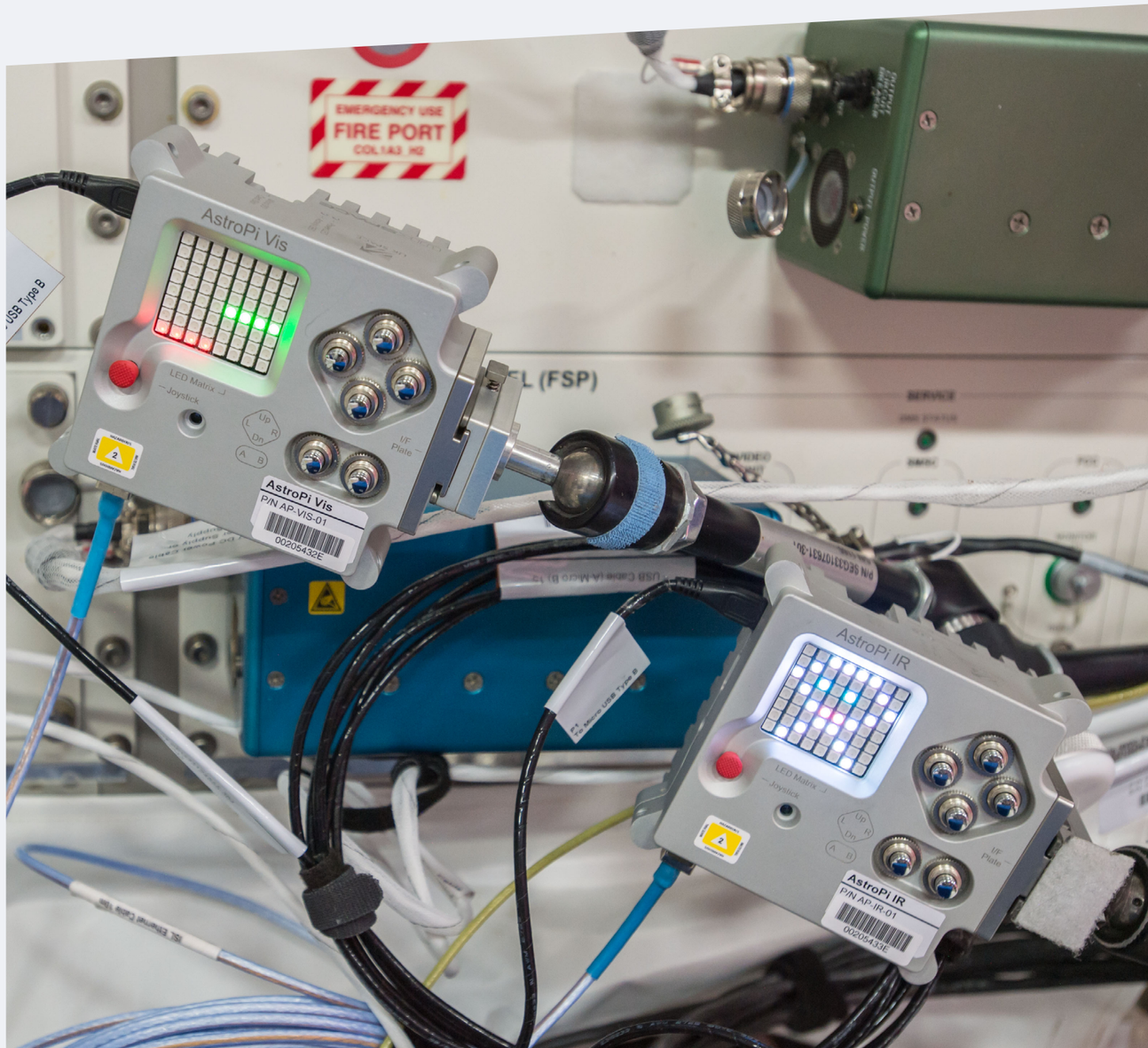
Once all the programs have been tested, we will email you about whether your team's experiment has achieved flight status (mid- to late April). We'll then prepare and upload the successful programs to the ISS, and we will notify you once your experiment has been deployed.

You will receive the results of your experiment via email once these have been downlinked from the ISS. This will happen by 6 May.

Please note that the above timings are dependent on ISS crew operations and are therefore subject to change.



Phase 4

→ ANALYSE
MAY 2020

Once you receive your results back from the Astro Pi team, it is time to analyse them and write your report. **Only teams that submit a report will receive participation certificates.** The ten teams with the best reports will be selected as the Astro Pi Mission Space Lab winners!

Your report needs to:

- Use the **Astro Pi official report template**
- Not be longer than four pages
- Be uploaded as a PDF

We cannot accept reports that do not follow these rules.

A couple of things to remember:

- If your program does not produce the results you were hoping for, we still encourage you to submit a report. You are still eligible for a prize, and you will still receive participation certificates.
- Your report does not need to be long or expertly written. We are looking for simple and clear explanations of what you did, what you discovered, and what you learned.

To analyse your data and produce your report, you could use the following process:

1 Data analysis

A. For tips on analysing data in CSV file format, see our **handy resource**

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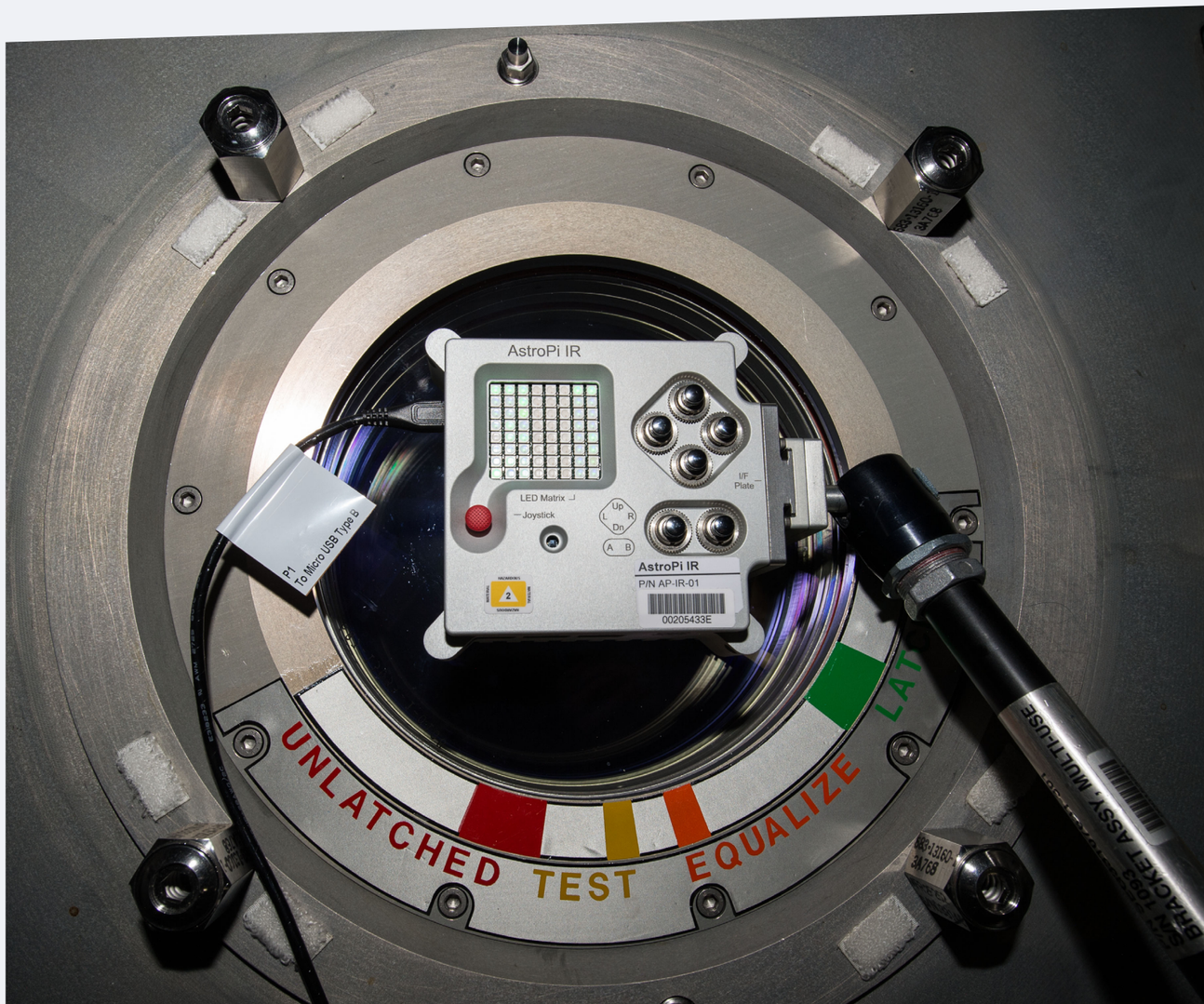
2 Report writing

A. Share the report template with your team, read through each section, and discuss what should go into each one

B. Divide the report up and allocate each section to one or two team members; write the sections

C. Put the sections together and read through the complete report as a team to ensure that it makes sense as a whole

The deadline for submitting your report is 27 May 2020. Winners will be announced in mid-June.



Thank you for your interest in the European Astro Pi Challenge: Mission Space Lab!

If you'd like more information, or updates on the challenge, head to: www.astro-pi.org

For resources and project ideas, head to: astro-pi.org/resources

If you have any questions, you can reach the Astro Pi team at astropi@esa.int or follow us on Twitter @astro_pi

The European Astro Pi Challenge is an ESA Education programme run in collaboration with the Raspberry Pi Foundation.

For more information on ESA Education programmes, head to: www.esa.int/Education

For more information on the Raspberry Pi Foundation, head to: www.raspberrypi.org