ASTRO PI

→ EUROPEAN ASTRO PI CHALLENGE 2020/21 MISSION SPACE LAB GUIDELINES

esa Raspberry Pi

→ 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.

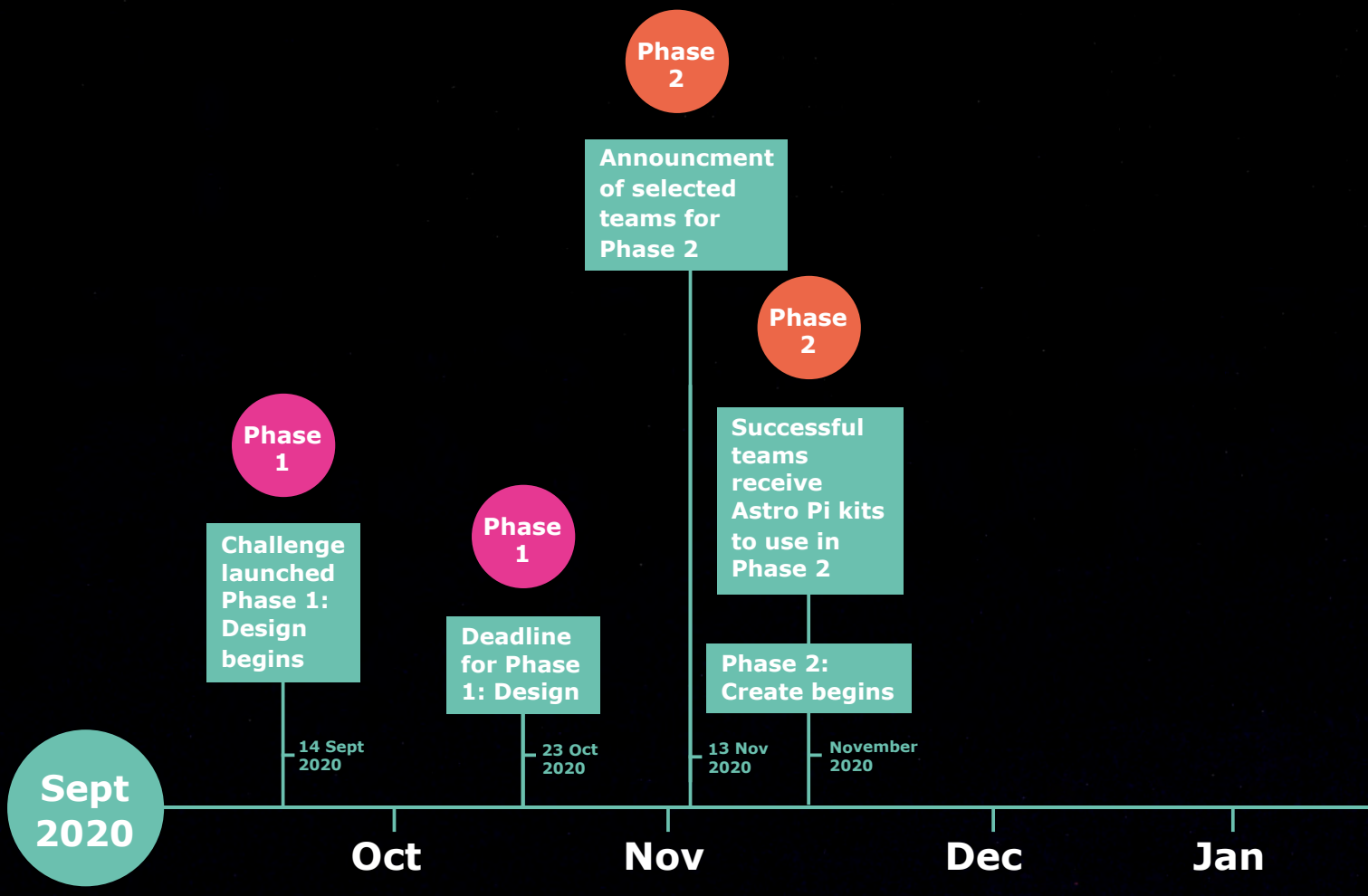
Mission Space Lab consists of four phases:

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

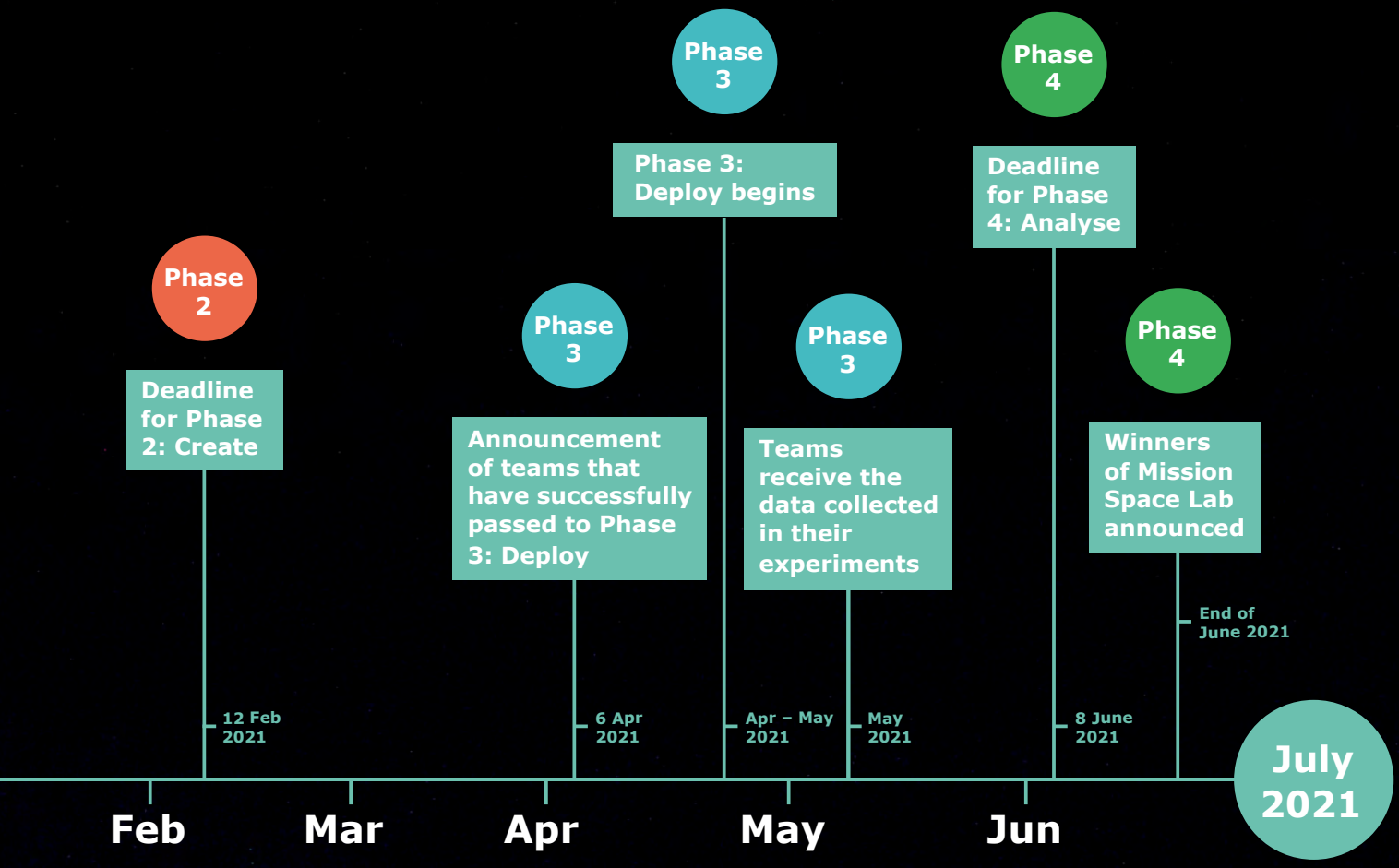
Phase 2
Create
Write the program for your experiment and test it on Earth.

Phase 3
Deploy
Your program is deployed on the ISS.

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


Phase 2
Announcment of selected teams for Phase 2
Phase 2
Successful teams receive Astro Pi kits to use in Phase 2
Phase 1
Challenge launched Phase 1: Design begins
Phase 1
Deadline for Phase 1: Design
Phase 2: Create begins
14 Sept 2020
23 Oct 2020
13 Nov 2020
November 2020
Sept 2020
Oct
Nov
Dec
Jan

→ OVERVIEW


Phase 2
Deadline for Phase 2: Create
12 Feb 2021
Phase 3
Announcement of teams that have successfully passed to Phase 3: Deploy
6 Apr 2021
Phase 3
Phase 3: Deploy begins
Apr – May 2021
Phase 3
Teams receive the data collected in their experiments
May 2021
Phase 4
Deadline for Phase 4: Analyse
8 June 2021
Phase 4
Winners of Mission Space Lab announced
End of June 2021
Feb
Mar
Apr
May
Jun
July 2021

→ CHALLENGE OVERVIEW

Phase 1

Design
(14 September – 23 October 2020)

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 23 October 2020 to register and submit their idea on the Astro Pi website.

We will notify the selected teams of their acceptance to Phase 2 on 13 November 2020.

Phase 2

Create
(13 November 2020 – 12 February 2021)

In Phase 2, which will take place between 13 November 2020 and 12 February 2021, 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 astro-pi.org) is 12 February 2021.

Phase 3

Deploy
(April – May 2021)

In this phase, the best experiments will be selected to receive 'flight status', and we will notify the teams that created these on 6 April 2021. 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 – May 2021 (depending on ISS operational constraints). Then the experimental data collected in orbit will be downlinked and distributed to the participating teams.

Phase 4

Analyse
(May – 8 June 2021)

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 **8 June 2021**.

→ 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 Canada, Latvia, Slovenia, 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 Canada, Latvia, Slovenia, or Malta
- Homeschooled (certified by the National Ministry of Education or delegated authority in an ESA Member State or in Canada, Latvia, Slovenia, 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 Canada, Latvia, Slovenia, 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 submissions must be in English.

[1] **ESA Member States in 2020:**
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 schools outside Europe officially recognised by the French Ministry of Education or delegated authority).

Phase 1

→ DESIGN 14 SEPTEMBER – 23 OCTOBER 2020

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**. Watch this video to make sure you understand all the requirements: **youtu.be/aac5IUPddOk**

→ 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. The team name should also only have alphanumeric characters — no symbols.

5 **Wait for our confirmation**

We will notify all teams about whether their experiment idea has been accepted for the next phase on 13 November.

Phase 2

→ CREATE 13 NOVEMBER 2020 – 12 FEBRUARY 2021

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 on 13 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 will contain the same hardware that is included in the Astro Pi units on board the ISS, except that your kit will contain newer, more powerful versions of the Raspberry Pi computer and Raspberry Pi Camera Module than those on the ISS (and will not include a special space-hardened case).

   You should bear these differences in mind when designing your experiment, and refer to the program checklist and Mission Space Lab Phase 2 guide for more detailed information.

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 3 programming language.
- Use the Sense HAT LED matrix ('Life in space' only).
- Use at least one Sense HAT sensor or the Camera Module.
- Use only the Python modules available on the Flight OS.
- Save results in log files for you to analyse later, as outlined in the coding requirements. Files should not be opened in other areas of the SD card directory structure. Data should be written to disk regularly during the three-hour experiment.
- Be designed for the actual Astro Pi hardware on the ISS. The hardware provided in the Astro Pi kits includes versions of the Raspberry Pi computer and Camera Module that are newer and more powerful than the ones on the ISS.

  The key differences are:

  - The Camera Module supplied in the kits can take photos with a higher resolution than the Astro Pis on the ISS
  - The Raspberry Pi computer supplied in the kits has more available memory and a faster processor, so it will be able to process more data more quickly than the Astro Pis on the ISS

  More detailed information is provided in the Mission Space Lab Phase 2 guide, along with instructions for testing your experiment using a version of the Raspberry Pi operating system that more closely reflects the Astro Pis' capabilities.
- Run for a maximum of three hours and terminate cleanly.
- Be likely to succeed in the three-hour window and not require an unusual or infrequent event to occur (e.g. passing over a particular location).

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

- Please upload your program files in a zip file. If you have additional files that are required for the operation of your experiment, they can be included in the zip file too, but the zip file must contain a file called main.py, which must be how your program is run.

→ PROGRAM CHECKLIST: Your program must not:

- Contain any malicious code (any code in any part of a software system or script that is intended to cause undesired effects, security breaches, or damage to a system).
- Require any additional equipment or resources other than the Astro Pi computer.
- Contain bad language or profanity.
- Use an absolute path for saving or reading files.
- Consume more than 3GB of storage space for the results.
- Create any data files that are individually larger than 30MB.
- Open a socket, or attempt any networking connection, or attempt to communicate across a network interface.
- Attempt to cause damage to the Astro Pi computer or other equipment.
- Attempt to interfere with the operation of the Astro Pi computer or other equipment.
- Attempt to spawn other programs, or attempt to start or interfere with system processes.
- Contain any precompiled code or obfuscated code.
- Use multithreading.

→ PROGRAM CHECKLIST: Your program must not:

- Depend on human interaction, such as a key press, to start, or as part of the experiment.
- Save photo or video files containing images of the interior of the ISS.
- Run for more than three hours. Experiments that exceed three hours will be terminated and lose data.
- Use file names that do not meet the requirements listed in the Phase 2 guide.
- Need to be started at a particular time or on a particular date.
- Require the ISS to be passing over a particular location on Earth.

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 – MAY 2021

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

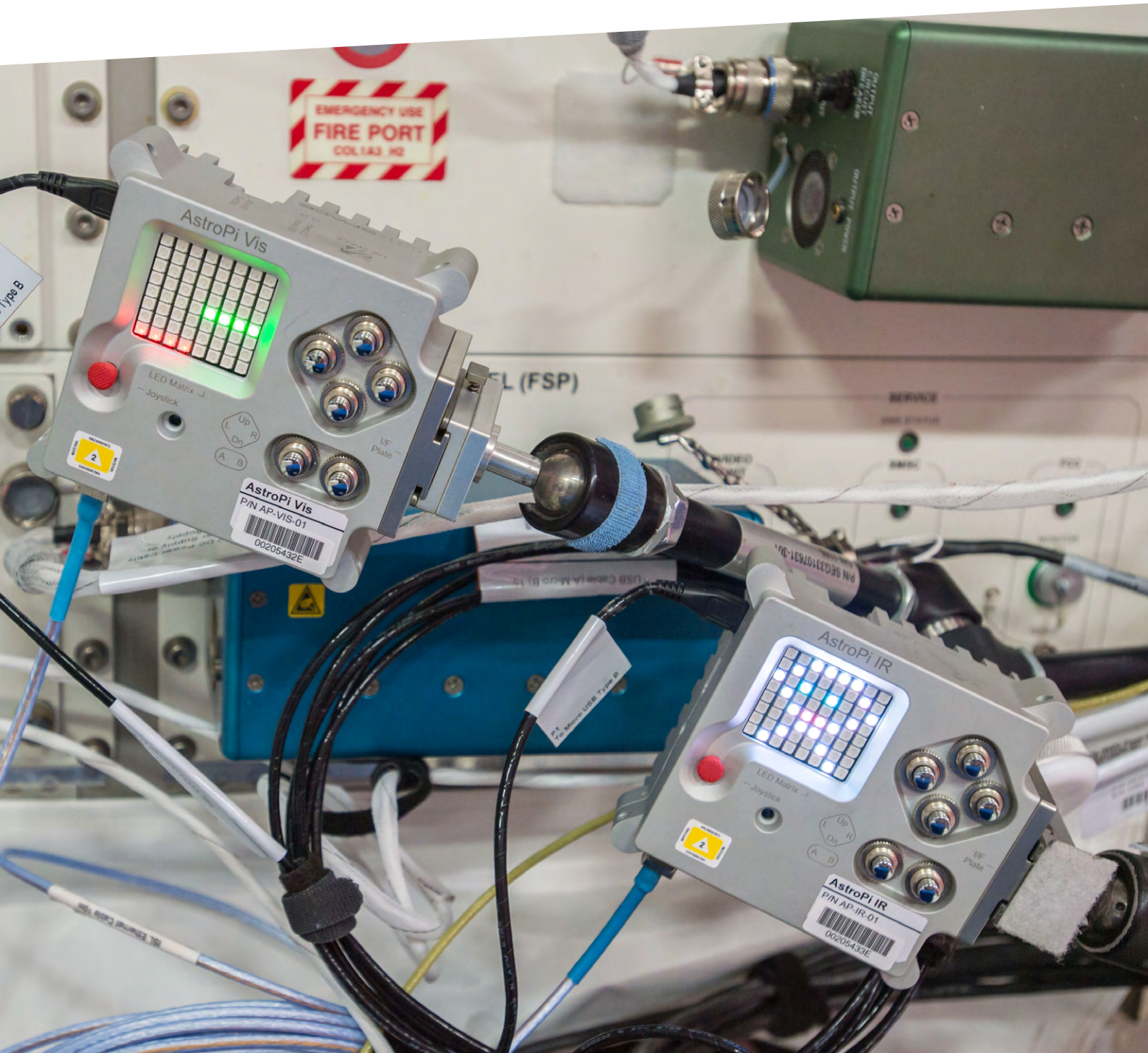
- **Scientific value**
  - Is your experiment investigating a scientific concept or principle?
- **Program readability and quality**
  - Is your program easily understandable?
  - Is it using comments and/or docstrings?
  - Is it structured well, and does it include rigorous error checking?
  - Is reused 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.

Once all the programs have been tested, we will email you about whether your team's experiment has achieved flight status (6 April 2021). 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 in May 2021.

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



Phase 4

→ ANALYSE

MAY – JUNE 2021

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**

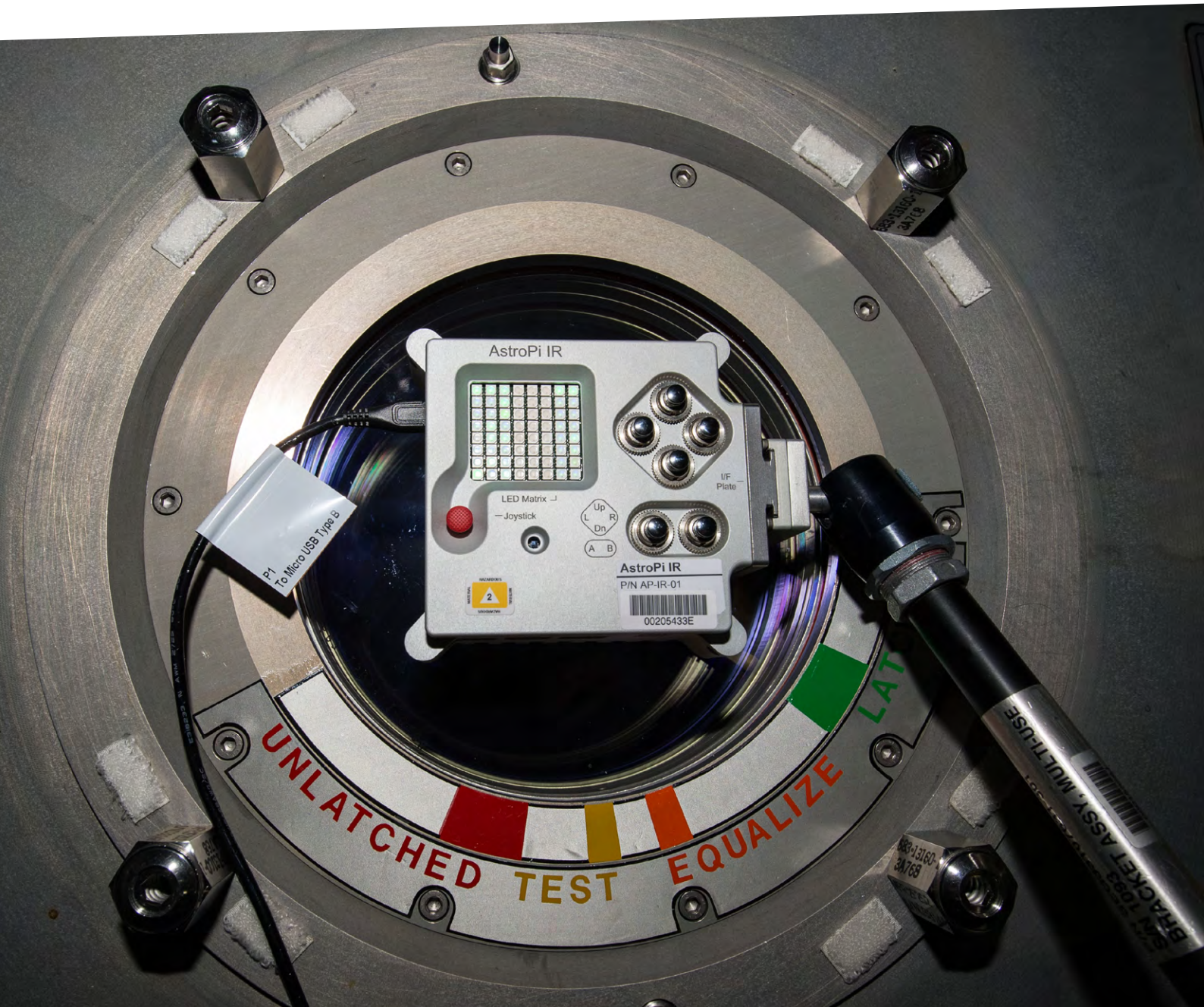
2 Report writing

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 **8 June 2021**. Winners will be announced at the end of 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 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

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MISSION SPACE LAB