# EUROPEAN ASTRO PI CHALLENGE 2022/23 MISSION SPACE LAB GUIDELINES

Raspberry Pi Foundation

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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 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 participating 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, making use of the sensors available (**https://astro-pi.org/about/the-computers**). The best experiments will be deployed on 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 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.

# CHALLENGE 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 one of the Astro Pi computers and its sensors 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 one of the Astro Pi computers and either the near-infrared camera (with a red optical filter) or the visible-light camera 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.

# CHALLENGE OVERVIEW

Phase 1

## Design

**12 September – 28 October 2022**

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 28 October 2022 to register and submit their idea on the Astro Pi website. We will notify the selected teams of their acceptance to Phase 2 in mid November 2022.

Phase 2

## Create

**Mid November 2022 – 24 February 2023**

In Phase 2, 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. If any of your teams are selected to participate in Phase 2 of the challenge, you will receive an exclusive Astro Pi kit directly to your 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 is 24 February 2023. Submissions are made by team mentors via their Mission Hub. **http://missions.astro-pi.org/**.

Phase 3

## Deploy

**April – May 2023**

In this phase, the best experiments will be selected to receive 'flight status', and we will notify the teams that created these on 17 April 2023. The selected entries will be uplinked to the ISS and deployed on the Astro Pi computers on board. The programs will run on the ISS in April – May 2023 (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 – 23 June 2023**

Congratulations to all teams that have made it this far! The challenge now for teams is 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. 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 team's final report is 23 June 2023.

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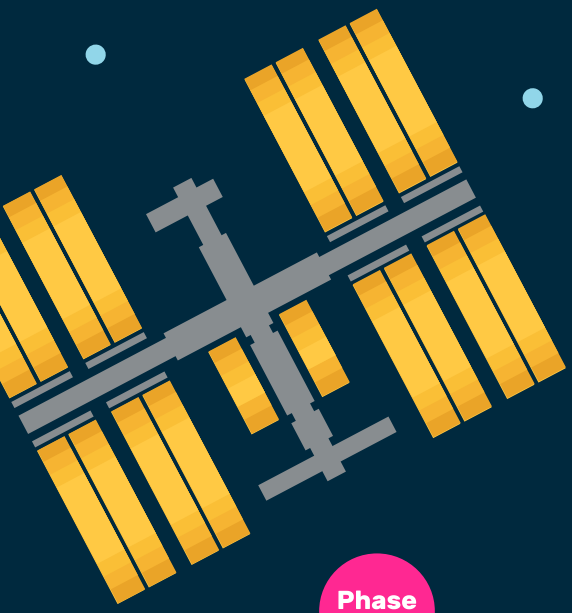
# OVERVIEW



**Phase 1**

Challenge launched
Start of Phase 1: Design

12 Sept 2022

**Phase 1**

Deadline of Phase 1: Design

28 Oct 2022

**Phase 2**

Announcement of teams selected for Phase 2

Mid-Nov 2022

**Phase 2**

Selected teams receive Astro Pi kits

Start of Phase 2: Create

Nov 2022

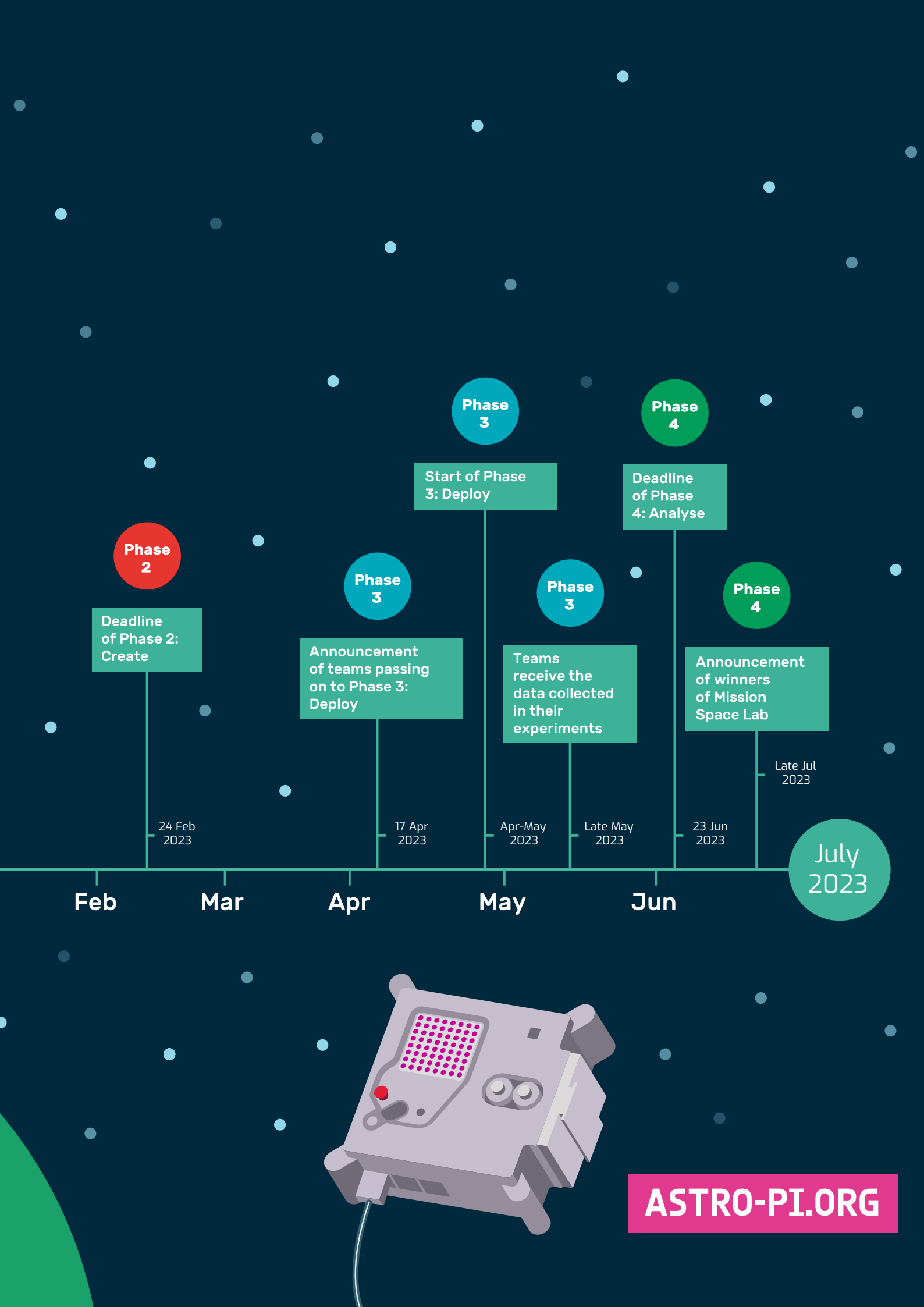
Sept 2022

Oct

Nov

Dec

Jan


Phase 2
Deadline of Phase 2: Create
24 Feb 2023
Phase 3
Announcement of teams passing on to Phase 3: Deploy
17 Apr 2023
Phase 3
Start of Phase 3: Deploy
Apr-May 2023
Phase 3
Teams receive the data collected in their experiments
Late May 2023
Phase 4
Deadline of Phase 4: Analyse
23 Jun 2023
Phase 4
Announcement of winners of Mission Space Lab
Late Jul 2023
Feb
Mar
Apr
May
Jun
July 2023
ASTRO-PI.ORG

# RULES FOR PARTICIPATION

**To take part, teams must:**

- Include participants aged 19 or younger at the time of submission
- Be made up of of 2-6 young people
- Be supervised by a mentor such as a teacher, parent, Scout leader, or Code Club or CoderDojo leader, who will need to register for a **Mission Hub** and will be the main point of contact with the Astro Pi team
- Include at least 50% of team members who are citizens of an ESA Member State, Canada, Latvia, Lithuania, Slovakia, 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, Canada, Latvia, Lithuania, Slovakia, Slovenia, or Malta
- Homeschooled (certified by the National Ministry of Education or delegated authority in an ESA Member State, Canada, Latvia, Lithuania, Slovakia, 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, Canada, Latvia, Lithuania, Slovakia, Slovenia, or Malta

One mentor may supervise a maximum of five teams per year. If one or more of a mentor's teams reach Phase 2 of the challenge, the mentor will receive one Astro Pi kit.

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

All submissions must be in English.

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

Phase 1

# DESIGN
# 12 SEPTEMBER – 28 OCTOBER 2022

Phase 1 is all about your team coming up with an idea for an experiment you want to run on the Astro Pis on board 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 young people, aged 19 years or younger, and half the team must be citizens of an eligible country.

   Each team needs a 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 one of the Astro Pi computers to investigate life inside the Columbus module. If you choose this theme, you will need to submit an experiment idea that makes use of the Astro Pi's LED matrix and at least one of its sensors.

You may only use the camera as a sensor for 'Life in Space' experiments, teams cannot store photos or videos. Teams undertaking a LiS experiment will not receive a camera with their kit unless their experiment design specifically requires it.

**Theme B – Life on Earth**
An experiment in this theme will investigate life on the planet's surface using one of the Astro Pi computers, which will be deployed in front of an Earth-facing window on the ISS.

If you choose this theme, you will need to submit an experiment idea that makes use of the Astro Pi's camera. You will also need to select what type of photography you undertake: you can use the near-infrared camera (with a red optical filter) or the visible-

light camera. It is important to note that your entire three-hour experiment will run solely on one Astro Pi, so you cannot use both the near-infrared and visible-light cameras. Use of the Astro Pi's sensors is optional for 'Life on Earth' experiments.

If you are conducting a 'Life on Earth' experiment, you must not use the Astro Pi's LED matrix, as light from the LEDs can spoil the photographs you capture. The LED matrix will be disabled during 'Life on Earth' experiment deployment to prevent this from happening.

## 3 Design your experiment together

### A. Preparation

Essential: Phase 1 checklist
Your idea must fulfil the criteria in the following checklist, **otherwise your experiment may be disqualified**. Watch this video that will help you to understand all of the requirements: youtu.be/owcZeUnSixM

## 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 should be a scientific experiment, not a game.
- 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: it is 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 only. Many teams that have attempted this in the past have obtained entirely black images that couldn't be analysed. The new hardware may improve opportunities for night-time photography, but this has not been fully tested at this time.
- 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 124 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.

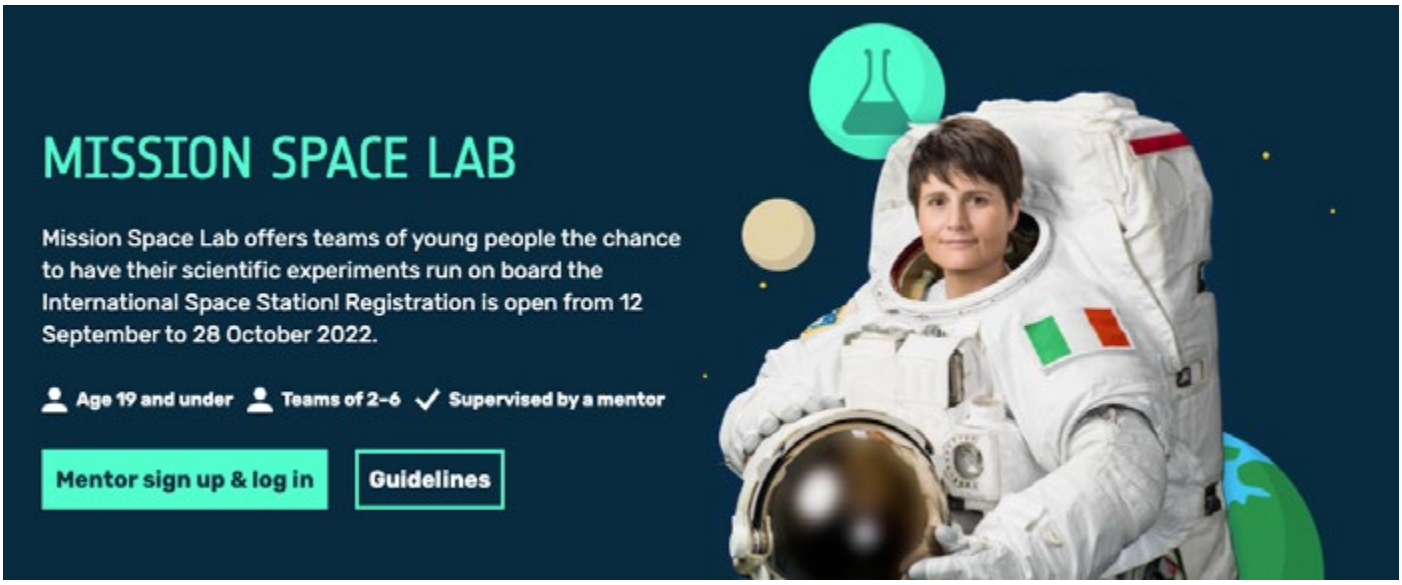
**ii.** Once everyone has had an input, it's time to group the ideas according to themes or categories: sort the sticky notes to cluster similar ones together. While you do this, talk through the ideas as a team. Once you've sorted everything, you may wish to vote on which idea your team wants to pursue: 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 **Register as a mentor and submit your team's experiment idea**

Head to the **Mission Space Lab web page** (**astro-pi.org/mission-space-lab**) to register as a mentor via the "Mentor sign up" button.

You will then need to register your team(s) and their participants via an online form.




# WHY NOT REGISTER TODAY?

Once you have registered your team(s) on our system, you will be able to submit their experiment ideas. You will need to answer these two questions for each team:

**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 in mid November 2022.

# Phase 2

# CREATE
# NOVEMBER 2022 – 24 FEBRUARY 2023

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 in mid November 2022.

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. Each mentor will receive one kit only. This kit will contain the same hardware that is included in the Astro Pi computers on board the ISS*, and additional components that will differ depending on the type of experiment that your team wants to conduct.

   You should refer to the program checklist in this document and the **Mission Space Lab Phase 2 guide** (**rpf.io/ap-msl-guide**) for more detailed information.

3. **Create your experiment: program checklist**
   Read our comprehensive **Mission Space Lab Phase 2 guide** (**rpf.io/ap-msl-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** (**astro-pi.org/mission-space-lab/resources**) that go into more detail on using the Astro Pi hardware to write the program for your experiment.

*The camera lens supplied with Astro Pi kits is 6 mm, whereas the default configuration for 'Life on Earth' experiments on the Astro Pis on board the ISS is with a 5 mm camera lens.

# PROGRAM CHECKLIST:

## Requirements: General

- Your experiment does not rely on interaction with an astronaut.
- Your program is written in Python 3 and is named `main.py`. It must run without errors when executed on the command line of the Flight OS using `python3 main.py`.
- Your program does not rely on any additional libraries other than those listed in the **Phase 2 guide** (**rpf.io/ap-msl-guide**).
- Your program monitors its running time and stops after three hours have elapsed.
- There is no bad language or rudeness in your program.
- Your program uses at least one Sense HAT sensor or the camera.
- Your experiment should 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).
- Your program is uploaded 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:

## Requirements: Security

- Your program is documented and easy to understand. There is no attempt to hide or obfuscate what a piece of code does.
- Your program does not contain malicious code, i.e. code that deliberately attempts to disrupt system functionality.
- Your program does not start a system process, or run another program or any command usually entered on the terminal, e.g. `vcgencmd` .
- Your program does not use networking.

## Requirements: Mission specific

- If you choose the 'Life in space' theme, your program should make sure that no captured images or videos remain stored in the experiment folder after the end of the experiment.
- If you choose the 'Life in space' theme, your program should regularly display messages or images on the LED matrix, to indicate that an experiment is running.
- If you choose the 'Life on Earth' theme, your program should not use the LED matrix.

## Requirements: Files and threads

- If your program employs threads, it does so only by using the `threading` library. Threads are managed carefully, closed cleanly, and their use is clearly explained through comments in the code.
- Your program only saves data under the folder where the main Python file is, as described in the Phase 2 guide. No absolute path names are used.

# PROGRAM CHECKLIST:

- Any files that your program creates have names that only include letters, numbers, dots (.), dashes (-), or underscores (_).
- Your program does not use more than 3GB of space to store data.

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

**Programs that don't respect this checklist will be disqualified.**

4 **Submit your program**

To submit your program, log into your **Mission Hub**. For each of your registered teams that has progressed to Phase 2, you will need to:

**A.** Upload your team's program

**B.** Answer the following:

**i.** What are the main objectives of your team's 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 2023

Once you have submitted your program, it will be judged by our expert panel.
They will assess 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?
  - Does it use 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 on board 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 (17 April 2023). We'll then prepare and upload the successful programs to the ISS. You will receive the results of your experiment via your Mission Hub once your experiment data has been downlinked from the ISS. This will happen in late May 2023. Please note that the above timings are dependent on ISS crew operations and are therefore subject to change.

Phase 4

# ANALYSE
# MAY – JUNE 2023

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

Your report must:

- Use the Astro Pi official report template found here: **https://astro-pi.org/mission-space-lab/guidelines/phase-4**
- Not be longer than four pages
- Be uploaded as a PDF

## OPTIONAL:

In addition to your report, your team(s) can also choose to submit a link to a GitHub repository that contains any additional code or programs that they have used to analyse their experiment data. This additional code will be taken into consideration by the Astro Pi judges when evaluating the teams' final reports. However, this is entirely optional and you are not required to submit any additional code.

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, reflecting on what you might do differently next time. 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.

Here are some ideas to help you analyse your data and produce your report:

1. **Data analysis**
   For tips on analysing data in CSV file format, see our **handy resource** (**rpf.io/astro-pi-fda**)

2. **Report writing**
   We recommend the following process for writing your final report:

   **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 **23 June 2023**. Winners will be announced in late-July.

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## 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**

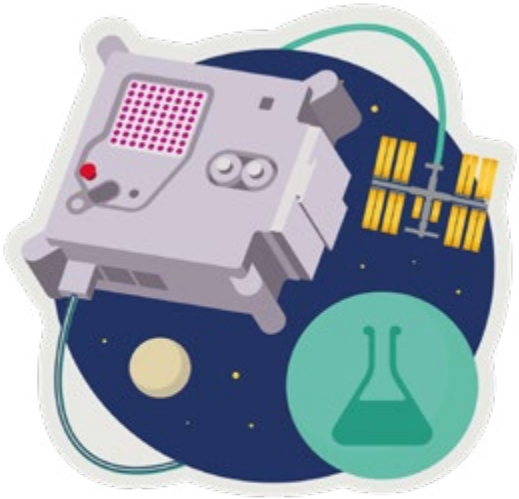
If you have any questions, you can reach the Astro Pi team at:
**enquiries@astro-pi.org**

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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