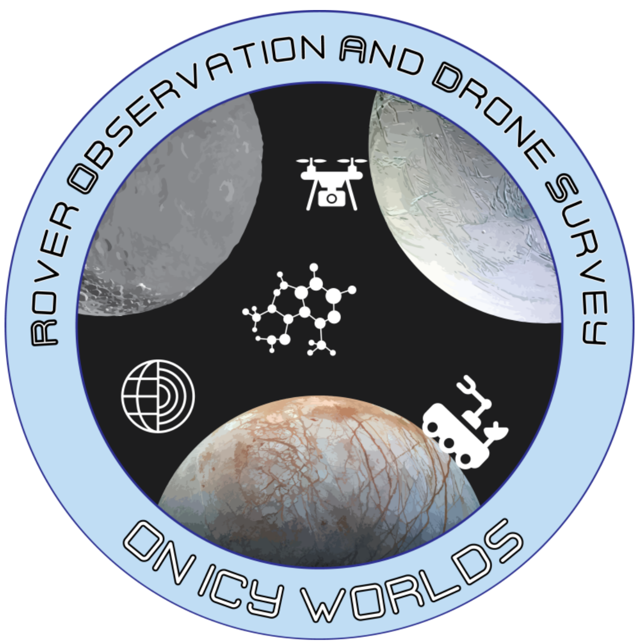
NESSP Mini-Mission

ROADS on Icy Worlds



Summer, 2022

About Northwest Earth and Space Sciences Pathways

The Northwest Earth and Space Sciences Pathways (NESSP) brings NASA science to K-12 students throughout the northwest. Funded through NASA's Science Mission Directorate, NESSP's (pronounced "NESPy") goals are to strengthen science, technology, engineering, and math (STEM) education region-wide and to serve as a bridge into other NASA experiences for educators and students.

NESSP's programming is available to communities across the northwest region. We especially welcome relationships with educators from underserved and underrepresented communities to cocreate STEM exploration opportunities.

Through our ROADS national student challenges, we also offer our programming to students and educators across the United States.

Contact NESSP

NESSP is headquartered at Central Washington University in Ellensburg, Washington.

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Partner

We want to see NESSP in action!

Share photos, videos, and comments related to your experience by emailing us or tagging us on social media:

- Email: info@nwessp.org
- Instagram, Facebook, YouTube and Twitter: @nwessp

About ROADS on Icy Worlds Mini-mission

Our ROADS program (**R**over **O**bservation **A**nd **D**rone **S**urvey) is a framework that lets students explore STEM concepts through hands-on activities. ROADS takes inspiration from real NASA projects and guides students on a space-related mission. Each year we update ROADS to tackle different science and engineering problems and to visit different solar system bodies. For 2021–2022 we're going to icy worlds!

Activities:

- Creating mission documentation
- Use provided calculations to create your own map of an icy moon site
- Explore planetary surface and remote sensing
- Take biological samples and explore them with a microscope
- Operate a drone to simulate space flight
- Robotics & programming — use a robot to navigate your map

Materials:

A primary goal of NESSP is to provide supplies and experts to educators in underserved communities. All of the materials listed on the first page of each lesson are available for loan. Please do not hesitate to request supplies and access to an experienced educator in your region by filling out the form here: https://nwessp.org/programs/mini-missions/

Stipends for Mini-mission Instructors:

NESSP will provide stipends to instructors and co-instructions leading a week-long mini missions.

- 8 to 15 students: One $1,200 stipend for the instructor
- 15 to 40 students: One $1,200 stipend for the lead-instructor and a $1,000 stipend for a co-instructor

To register for stipends instructors must https://nwessp.org/programs/mini-missions/ and fill out the registration form.

Resources for additional information:

There are numerous sites that students and educators can use to learn more about Icy Worlds. We suggest starting with the list below:

- Europa and Europa Clipper: https://europa.nasa.gov/
- NASA's Ocean Worlds: https://www.nasa.gov/specials/ocean-worlds/
- NASA's Europa Trek: https://trek.nasa.gov/europa/

Providing feedback, corrections, and success stories:

NESSP strives to develop material and programs that are effective for teachers and students. Please feel free to share your feedback by emailing us directly at info@nwessp.org.

Getting Started

Team Descriptions and Selections

At the beginning of the camp you should split students into groups of four to five. It is important to maintain and manage these groups as the week progresses. Learning how to work as a team and divide tasks when necessary is an important part of the mission. Also, consider distributing students that have experience with robotics and programming evenly throughout the teams.

It is important to establish rules of the road or protocols for how students should interact with one another and you. Groups should be carefully monitored so that all students get to participate in all aspects of the project. In some cases, it can be beneficial to give students leadership roles in specific aspects (science lead, robotics lead, drone lead, etc.) to ensure that all students have a role.

We packed the schedule of this camp intentionally! Busy students are happier than bored ones! However, make sure to carefully monitor the students and give them breaks as needed. Feel free to remove some of the educational blocks and replace it with a fun activity that you have available (pool time anyone?) or remove blocks to provide more time for programming robots or practicing flying drones. You know your students best!

Mission Overview

The students will spend the week completing a series of hands-on activities that mimic aspects of planning a rover mission to an icy world like Europa. The activities are a mix of science and engineering with lots of hands-on, student-lead activities. Lecturing is discouraged, since it is more important that students get the experience of *doing* science rather than learning specific concepts. It should be fun!

At the beginning of the week students will get started on their Mission Development Log. This log is meant to teach students the importance of documenting their work. For each block of work, we will provide suggestions for what students should include in their MDL; however, as the instructor, feel free to set your own guidelines or provide your own prompts to the students. A simple reflection at the end of each activity can be appropriate and will help students synthesize what they have learned.

If computers with the internet are available, we recommend students using Google Slides (or Docs) to document their work. Later they can turn their "log" into a short presentation to share out. If computers or the internet are not available or appropriate, students can document their progress on paper or in a notebook and a final presentation could be a show and tell of products of their mission.

The first task the students will accomplish is constructing a map on the floor that will be the course for their drone and rover in the final challenge. In the months-long challenge, NESSP provided several ways to provide map information to students. Since time is limited in the mini-mission, we recommend providing them with the map and having them scale it up. How elaborate students get with the map depends on the resources available. Drawing on butcher paper or even masking tape on carpet works well in a pinch.

Next, students will complete activities that will introduce the students to important science topics related to an Icy Worlds mission including geology, astrobiology, and remote sensing. Each of these activities can be adapted or even skipped based on the space and resources available.

Finally, students will learn how to fly the drone and program the robot. The robot and drone will be used in the final challenge, which will be videoed, scored, and timed as part of the students submission to NESSP. If you are not familiar with programming robots or flying drones, don't stress! NESSP has experts that can provide support both before the mini-mission and during the week. Students also pick up these concepts surprisingly quickly!

Good luck!

Suggested Schedule

The following schedule is broken into a series of educational blocks described in this manual. Green sections are adapted from the ROADS on Icy Worlds Companion Curriculum. Blue sections are adapted from the ROADS on Icy Worlds Mission Objectives. Pink sections highlight additional education activities that we recommend. Finally, yellow sections are extra fun activities related to the camp. Green and blue sections are described in the main portion of the manual and pink sections are described in the appendix.

For more information on the green block, see the associated lessons that are part of the ROADS on Icy Worlds Companion Curriculum: https://nwessp.org/curriculum/roads-on-icy-worlds-companion-curriculum

For more information on the blue blocks, see the associated Mission Objective in the ROADS on Icy Worlds Challenge Manual: https://nwessp.org/wp-content/uploads/2022/05/ROADS-on-Icy-Worlds-Official-Manual-English-2021.pdf

<table>
<tr><th></th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>8:30 AM</td><td rowspan="2">Check-in</td><td rowspan="2">Check-in</td><td rowspan="2">Check-in</td><td rowspan="2">Check-in</td><td rowspan="2">Check-in</td></tr>
<tr><td>8:45 AM</td></tr>
<tr><td>9:00 AM</td><td rowspan="3">Team Descriptions & Selections</td><td rowspan="12">Limits of Life</td><td rowspan="4">College Admissions & Scholarship Search or College Student Panel</td><td rowspan="4">Science Matter Expert Presentation</td><td rowspan="8">Final Challenge Practice</td></tr>
<tr><td>9:15 AM</td></tr>
<tr><td>9:30 AM</td></tr>
<tr><td>9:45 AM</td><td rowspan="2">Icy Worlds/Mission Overview</td></tr>
<tr><td>10:00 AM</td><td rowspan="5">Rover build</td><td rowspan="8">Drone and Rover Practice, MDL Presentations Work Time</td></tr>
<tr><td>10:15 AM</td><td rowspan="3">Communications in Complex Projects</td></tr>
<tr><td>10:30 AM</td></tr>
<tr><td>10:45 AM</td></tr>
<tr><td>11:00 AM</td><td rowspan="4">Mission Development Log</td><td rowspan="4">Final Challenge</td></tr>
<tr><td>11:15 AM</td><td rowspan="3">Programming & Robots</td></tr>
<tr><td>11:30 AM</td></tr>
<tr><td>11:45 AM</td></tr>
<tr><td>12:00 PM</td><td rowspan="3">Lunch</td><td rowspan="3">Lunch</td><td rowspan="3">Lunch</td><td rowspan="3">Lunch</td><td rowspan="3">Lunch</td></tr>
<tr><td>12:15 PM</td></tr>
<tr><td>12:30 PM</td></tr>
<tr><td>12:45 PM</td><td rowspan="3">Group & Team Pictures</td><td rowspan="7">Remote Sensing</td><td rowspan="7">Programming & Robots</td><td rowspan="8">Team Mission Patch</td><td rowspan="5">Finish MDL Presentation</td></tr>
<tr><td>1:00 PM</td></tr>
<tr><td>1:15 PM</td></tr>
<tr><td>1:30 PM</td><td rowspan="3">Explaining Europa's Surface</td></tr>
<tr><td>1:45 PM</td></tr>
<tr><td>2:00 PM</td><td rowspan="3">MDL Presentations</td></tr>
<tr><td>2:15 PM</td><td rowspan="11">Map Development</td></tr>
<tr><td>2:30 PM</td><td rowspan="10">Drone Development and Landing Site Selection</td><td>Review Final Challenge</td></tr>
<tr><td>2:45 PM</td><td rowspan="5">Drone and Rover Practice</td><td rowspan="9">Tie Dye Shirts</td><td rowspan="3">Awards</td></tr>
<tr><td>3:00 PM</td></tr>
<tr><td>3:15 PM</td></tr>
<tr><td>3:30 PM</td><td rowspan="2">Dismissal</td></tr>
<tr><td>3:45 PM</td></tr>
<tr><td>4:00 PM</td><td rowspan="4">STEM Career Exploration</td><td rowspan="7"></td></tr>
<tr><td>4:15 PM</td></tr>
<tr><td>4:30 PM</td></tr>
<tr><td>4:45 PM</td></tr>
<tr><td>5:00 PM</td><td rowspan="3"></td><td rowspan="3">Parent pickup / Dismissal</td><td rowspan="3">Parent pickup / Dismissal</td><td rowspan="3">Parent pickup / Dismissal</td></tr>
<tr><td>5:15 PM</td></tr>
<tr><td>5:30 PM</td></tr>
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Don't like this schedule? Download the the schedule and adjust it to suit your camps needs: ROADS on Icy Worlds Mini-mission Schedule

The Mini-Missions

Mini-Mission 1: Communication in Complex Projects

Full lesson: Unit1 L2 Communication 2021.docx

Estimated Time: 45 minutes

Summary: *Students will develop verbal and written communication skills and interpersonal skills necessary to work as a team to plan a mission. This activity serves as an ice breaker for the campers and will help motivate the Mission Development Log (MDL) activity coming up next.*

Before the mission:
- Decide on your 'Constraints' list in lesson
- Ensure all students have access to MDL template for reference
- *For MS:* 4-6 LEGO pieces, *For HS:* 5-7 LEGO pieces

Pair students, then have one student in each pair move to the other side of the classroom, so they can't see what their partner is doing.

Provide all students 4-6 pieces of Lego (or send a box of Lego pieces around the room and let each student choose 4-6 pieces). Tell the students to build a shape with their Lego pieces and write down directions for how to build that shape using their Lego pieces. The directions can be subject to various Constraints (rules), such as:
- Only written words (no diagrams) can be used and words for numbers or colors cannot be used. (most difficult)
- Only written words (no diagrams) can be used.
- Words and one diagram with no labels can be used.
- Words and a labeled diagram can be used.
- Only verbal instructions can be given, without the instructor being able to see what the builder is doing.
- Only verbal instructions can be given, with the instructor being able to see what the builder is doing. (least difficult)

To avoid the possibility of students forgetting what shape they built, have them produce a visual record (e.g. a picture, drawing, or replica built with additional legos).

Once all the students have built their shapes, created directions to reproduce the shapes, and created a visual record of the shape they built, tell the students to disassemble the shape they built (or one of the shapes they built if the fourth option above was used to create a visual record of their shapes) and then exchange their disassembled Lego pieces and directions with their partners.

Partners should then try to reconstruct the shape using the Lego pieces and instructions received from their partner.

After all the students have finished building the shapes according to their partners' directions, have the partners meet and examine their work. Did each partner correctly reproduce the original shape?

If not, were the directions unclear? What could have helped to get the shape correct? For those students whose shapes were not correctly built by their partners, ask the pairs to consider ways to improve the directions to avoid confusion!

Repeat the exercise two or more times, using a different set of constraints on the types of directions so that students can see the benefits of various forms of communications.

After all rounds are complete, ask students to consider which type of directions would be MOST difficult to follow, which would be the LEAST difficult to follow, and why.

- Only written words (no diagrams) can be used and words for numbers or colors cannot be used.
- Only written words (no diagrams) can be used.
- Words and one diagram with no labels can be used.
- Words and a labeled diagram can be used.
- Only verbal instructions can be given, without the instructor being able to see what the builder is doing.
- Only verbal instructions can be given, with the instructor being able to see what the builder is doing.

Mini-Mission 2: Mission Development Log

Full Lesson: Unit1 L3 Documentation 2021.docx

Estimated Time: 1 hour

Summary: *Students will consider the reasons and methods of preserving information for the future. Next, students will make a timeline and plan for their Mission Development Log (MDL). Finally, students will begin their MDLs in groups and enter important mission information.*

Before the mission:

- Prepare to project or share slideshow
- Provided electronic template or notebook, 1 per team

Part 1: *Students will examine a series of images to spark their thinking about the kinds of information it is important to record and various ways of recording information (writing, photos, drawings, tables, graphs, videos, etc).*

Display the slide show and ask students to think about the images and information shown. Give students 5 minutes to discuss the following questions with a partner:

- *What kinds of information are being recorded in each picture?*
- *How is the information being recorded?*
- *Why is that information being recorded?*

Take a few student responses for each photo.

Part 2: *Student teams will begin their own Mission Development Logs.*

Each group should prepare and then continuously update a Mission Development Log (MDL), either as a hard-copy book OR as an electronic repository. All team members are expected to contribute to the MDL.

If students will make a hardcopy MDL:
Give each group a blank notebook. If the pages of the notebook are not numbered, have the students number each page. Then, have students reserve the first three pages for a Table of Contents and begin their entries on page 4. See below for more information on what needs to be included in each entry in the Table of Contents.

If students will make an electronic MDL:
Your students can use any electronic format that works for them (Google Doc, Google Slides, Wordpress website, Google sites, etc), as long as it is organized and includes the required Table of Contents (see below). A Google Doc template is provided as a starting point. If you wish to use the

Google Doc, make a copy of the template file for each group, and ensure that you AND all group members have edit access. Make sure that if students are creating an electronic MDL, any linked files include "anyone can view" permission so that everyone can see them!

Regardless of which method students are using, each entry in their MDL should be have a corresponding entry in the Table of Contents with at least the following information:

- Brief title of the entry
- Date the entry was made
- Page number where the entry begins (Electronic format can include a link to the entry instead)

Mini-Mission 3: Explaining Europa's Surface

Estimated Time: 45 minutes

Summary: Students will explore the surface of Europa and explain its geological features.

Before the mission:

- Give students access to NASA Europa Trek or prepare to display it to the whole group
- Provide access to a print out or a link to the image of the challenge map

Part 1: *Students will explore Europa's surface and provide an explanation about the forces that affect the surface.*

Use NASA's Europa Trek to explore the surface of Europa. Pick a targeted area of Europa's surface, record the latitude and longitude of the location, and make a claim — about forces or processes that created the feature, the order features formed, or any other claim you can support with evidence from your work.

Part 2: *Students will explore real images of Europa and their explanations.*

Have students explore why scientists think Europa's surface looks the way it does using NASA Europa in Depth website. In particular, make sure the students read about the surface of Europa and examine real images of Europa and their captions.

Part 3: *Students will explore the challenge map and make claims regarding why the surface looks the way it does.*

Have the students spend some time looking again at the section of Europa we selected for the Icy Worlds mission site. You can display the map at the end of this guide or direct them to the Castalia Macula region in NASA Europa Trek. To do this click on the sheets on the top left and use the search function.

What features do the students notice on the map? What processes do they think might be causing those features? You can show these students where this location is on Europa by using the search function in the upper left corner of NASA Trek and looking for "Castilia Macula". Have them investigate the size of the features and where they are located on Europa generally,

In their MDL, have the teams document what they observed about the geology of the challenge map and any claims, evidence, and reasoning regarding why it looks the way it does.

Mini-Mission 4: Map Development

Estimated Time: 3 hours

Summary: *Students will create a scaled map of a room, then discuss the importance of maps. Then, they will work in teams to create the large scale map that they will need for the challenge.*

Before the mission:

- Provide graphing paper, 1 sheet per student
- Print out the challenge map, 1 per group
- Provide each group with 1-foot rulers and meter sticks (or tape measurers)
- Provide calculators, 1 per group
- Prepare to do one scaling example for the class (especially for younger students)
- Decide what materials the students will use to make/draw the map and provide them to each team of students

Part 1: *Students will create a scale model map of their work/instruction room*

Tell students they will be creating a scaled map of their classroom or room of instruction. Explain that the map should show a "top down" view, meaning how the room would look if they were hovering above it, and will need to be scaled to fit on an 8½" x 11" piece of graph paper (or the online equivalent if classes are being held remotely). Also explain how to create and apply a scale for a map.

Give students time and tools to measure various features (such as closets, shelves, doors and windows), furniture and other parts of the classroom and then time to create the scaled map.

Guide students in a discussion of the purposes maps serve, starting with the map of a room (such as planning for home improvement projects, figuring out where the furniture should go, etc). Expand to other maps, such as a map of a whole building, town, state, or planet. Ask students why people need maps, taking all ideas. If students struggle to come up with ideas, consider providing one or two of the following ideas to get them started.

- Planning for a variety of activities that involve movement from one location to another
- Studying geographic terrain and features
- Navigating from one point to another
- Delineating boundaries (e.g., country boundaries, voting districts, time zones, zip codes, telephone area codes)
- Analyzing various kinds of location-based data (e.g., counties with the highest population of various minorities or the prevalence of certain industries in various locations)
- Evaluating and predicting weather patterns
- Researching historical geography, building locations, land usage, etc.

NASA needs maps of other bodies before they send missions there. The student will make a scale model of the target area for our final mission.

Part 2: *Students will be given a scaled version of the challenge map and will use it to make measurements that will help them build the full scale map.*

The scaled version of the map (in the appendix) shows the location of barriers, landing zones, and sample sites on the full sized 5' by 8' map. Barriers are represented by black boxes, landing zones by concentric blue rings, and sample locations by white and yellow circles. (The yellow circle is included in case you choose to use color sensing). The red circle represents an area on the map called Castilia Macula, which is of particular interest to scientists because of its dark reddish color.

Students should use a ruler to measure the location of these objects on the scaled image and make calculations to figure out where they would be located on a full scale map. For example, by dividing the distance between one side of the image to the location of the center, they can obtain a fraction that will allow them to figure out the distance of that object on the full scale map.

Part 3: *Construct the full-scale map!*

Once all measurements and calculations are made, students can start working on their full scale map. What students build the map on is up to you and can depend on supplies that are readily available.

For example, students can use pieces of dark color foam board, cardboard, or heavy duty paper in sufficient quantity for the team to create an 5' by 8' map by taping the pieces together as needed; packing or other wide tape in sufficient quantity for the team to tape together the pieces to create an 5' by 8' map; and one set of the following: white, blue, green, and red markers, paint pens, pencils, or crayons for marking features on the map, a ruler (the longer, the better) or measuring tape in centimeters, and a protractor.

Note: The image provided here is the highest resolution image of this region of Europa available. It's from the Galileo spacecraft! If you decide to print it at full scale it will be pixelated.

In their MDL, students should include their graph paper (or an image of it) and a photo or two photos of the finished map taken from above.

Mini-Mission 5: Limits of Life

Full Lesson: Unit3 L3 Limits of Life.docx

Estimated Time: 3 hours

Summary: *Students will examine a series of images to decide which images show evidence of life and which do not. Then, they will assemble and use FoldScopes to find evidence of microscopic life. Finally, students will design and carry out experiments to determine the hardiness of yeast. Finally, students will use what they learned to construct a Yeast Identification Card.*

Before the mission:

- Prepare 'Life' Image set
- Prepare the extremophile cards, Mars environment cards, and icon ID key; one per group.
- Prepare materials sets (includes glassware (beakers, test tubes, or other clear glass containers); yeast, sugar, salt, thermometers, ice, heat source (hot plate, hot water); vinegar, acetic acid, and Tums (to alter pH); pH indicator or paper; balloons or rubber gloves (for capturing gas being generated by the yeast), digital camera (optional, for documenting experimental results)

Part 1: *Students will share ideas about a series of images, first trying to decide if the image shows something alive or not alive, and then sorting them into alive, once alive, and not from life.*

Either display the images in the image set OR make sets of cards for students to manipulate. Students should work in pairs if possible. Ask students to decide if the image shows life, evidence of past life, or no evidence of life. Students should be ready to give reasons for their decisions, and may find it useful to take notes. Do not explain what each image shows, let the students decide based on the image alone.

After 10 minutes, lead a discussion to surface student ideas. You can do this by going through each image and asking pairs to "vote" which category it is in, or by asking each pair to choose an image that they are least and most sure about. This should spark some interesting discussion, because some things are less clear (is a seed alive or is it evidence of past life?). Sugar and salt are also controversial, because clearly neither is alive now, but does the existence of sugar or salt prove the existence of past life? (Sugar, yes. Salt, no--it could have mineral origins.)

NASA is rarely looking for life on other bodies that are alive right now, and they are looking for signs of life that are very, very small.

Part 2: *Students will play a quick Yeast Identification card game that will introduce them to extremophiles.*

Hand out the extremophile cards and the icon ID key , one set per group of students, and give the groups about 5 minutes to read and examine the cards. Next, hand out the cards describing different environments on Mars. Give the students some time to examine them and have the students match the extremophile cards to an environment where they believe that organism could live.

Part 3: *Students will design and carry out experiments with yeast to determine the limits of life for this hardy organism.*

Each team will choose one variable and test the hardiness of yeast.

Show students the range of equipment that they have for these experiments, which will likely help them choose their variables. For example, seeing that they have thermometers, pH paper, and salt should give them the ideas to test how the yeast responds to differences in temperature, pH, and salinity.

Ask students how we could create and measure some of the variables involved (heat/cold, salinity, acidity/alkalinity). Be sure they know that each group is only going to test one variable, keeping all other variables the same. If possible, divide the groups up so that temperature, salinity, and pH are tested over a range of conditions. If you have a large number of groups, each group only has to test two conditions (such as two different temperatures), and later they can combine their data. If you have a small number of groups, they will have to test more conditions (such as several different temperatures) and compare. NOTE: Yeast always needs sugar! This could be another variable that a group chooses to test (sugar vs no sugar), but all other groups need to add the same amount of sugar to the same amount of water for each sample they test!

Review and approve each group's investigation plan before giving them access to the materials. Supervise experimentation and data collection. At the end, have each group share their data.

Part 4: *Students will make an extremophile card based on their yeast experiments.*

In their MDL, document the findings of all groups by creating an identification card for yeast. The ID card will provide a quick, one-page overview of yeast's properties. Your team's ID card should include:

- A photo your team took of yeast (possibly taken through a microscope such as a Foldscope!)
- Symbols representing yeast's properties
- Text noting any other important information you learned about yeast
- A brief sentence on possible further experimentation

Mini-Mission 6: Remote Sensing

Full Lesson: (MS) Unit1 L4 Remote Sensing.docx

Estimated Time: 2 hours

Summary: *Students construct moons with different colors and terrain out of clay or paper. These moons are then imaged under different colored lights. Students will analyze the images to learn about the science of light and color. Students will connect what they have learned to NASA science by exploring how color imaging and filters are used to explore the composition of the surfaces of icy moons.*

Before the mission:

- Prepare to display the slide deck of the associated lesson (only selected slides will be shown)
- Watch the Instructional Video for help on how to build the box and run this activity
- Prepare the foam half spheres, clay, lights, and boxes (with holes in the sides for viewing of the moons)

Part 1: *Students will construct moons with 'terrain' made with different textures and color and then image the 'terrain' under different filters or colored lights.*

Split students into groups of 2-3. Each group will make a "moon" - the main objective is to produce features made of different colors and varying textures for other groups in the room to figure out later. **The groups should not view each other's moons during construction.**

Share this criteria for students to follow when making their "moon":

- At least 3 different types of terrain (smooth, wrinkled, cratered, rough)
- At least four different colors, including at least one primary color and white.
- It is OK if some of the underlying foam or cardboard is showing through.

When students are finished, have them place their moon models under the pre-cut cardboard boxes (1 box per moon). Have students swap their moon + box set with another group. Demonstrate to class how to use box cutouts and colored flashlights (or lights with gel filters) while viewing the moon. Remember to let in as little light as possible from the side flap.

Have students use cameras to take images and "collect remote data" of the moons by shining colored lights (or light with gel filters) through a cutout on top of the box while observing or taking photos from a different cutout on the side of the box. Each group should take a clear image or observe the moon from each hole for each color of light (3 colors x 7 cutouts = 21 images total per group). Emphasize to students that similar to spacecraft images, each image the students take will only show a portion of the moon, and they should not be viewing with "white" light at this point, only colored lights.

If you don't want to use a box, a simpler option would be to have students take the images of the moon yourself and distribute them to computers used by the student. Ask the students not to look at the image with the normal program. Instead have the students open the image using The Physics

Classroom RBG Color Addition Interactive. This interactive will automatically show what the image looks like under red, green, and blue filters, which produces the same results as using the flashlights. (Note: Ask students not to overlap the three images until after they have predicted the true colors of the moon using the steps below.)

Display the "Drawing a Map" slide from the Explore portion of the slide deck. Explain that the image on this slide is a geological map of Europa. Have students draw a map of the moon that they observed (not the moon that they made) with a similar level of detail.

Remind students of the following:

- Students should refer to the images they took of the moon they observed when drawing this map.
- Don't try to sketch every detail observed on their moons, instead sketch the outlines of regions, large features like craters and ridges, and shade (or keep white) regions that look dark (or bright) under all colored lights
- DO NOT include color in their map at this stage since they will determine the true color during the following portion of this lesson.

Once the global map is complete, have students choose three interesting and distinct regions on the map to analyze in more detail. They should make note of whether it is smooth or bumpy, if it contains cracks or ridges, etc and how each region looks under different lights. They should focus on whether the region looks bright or dark under the different colored lights.

Part 2: *Students will explore a color mixing simulation to help explain why the different colored regions looked different under different lights.*

Next display the "Phet Color Activity: Color Mixing" slide in the Explore portion of the slide deck. Provide the Phet Color Simulator link to students and have them select the 'RGB filters' option after hitting play. Have students play around with the different filters. Have them attempt to recreate the color of their shirt. As they are working, display the slide "Color Addition" , and have a discussion about the patterns students observe while they play with the filters. Give students about 10 minutes to examine how color mixing filters work using the Phet simulation. The students should be trying to understand why their moon looks different when illuminated by different colors. If computers are not available for each group, you can create larger groups per device or project the simulation and guide the class through it. Can students use what they learned to figure out the true color of each region?

Finally, display the "Let's Figure out Composition" slide in the Elaborate portion and explain how the color of the surface of the moon can tell us something about its composition. This is why scientists use different colors of light and different filters to observe planetary objects.

In their MDL, the teams include the drawing of the moon they observed, the colors of the different regions, and why the regions looked differently under different colored lights.

Mini-Mission 7: Drone Development and Landing Site Selection

Full Lesson: Unit4 L2 Drone Development

Estimated Time: 2.5 hours

Summary: *Students will first become familiar with their drone and basic drone flight. Then students will follow the Engineering Design process to brainstorm designs for a drone/satellite, test their designs, and then finalize the design to complete the assigned mission objectives.*

Before the mission:

- Make sure drones are fully charged
- Provide materials for students to build their payloads, such as construction paper, string, scissors, and paper clips
- Drone Setup - prepare to show Drone Safety 101 video before other videos on screen. Ensure class space is clear and spacious for drone usage, write prompts on board for reference.
- Prepare to review Engineering Design Process via link
- Provide directions for testing

Part 1: *Students will become familiar with their drone and the basics of how to fly it.*

Students should have plenty of space if flying the drone indoors.

Safety video to watch as a group prior to flight: https://www.youtube.com/watch?v=MsfRpiEFrVY

Watch the 'Drone Flight Physics in Under 2 Minutes Video' and 'Man Uses Drone to Locate And Rescue Dog Missing For 10 Days' videos

Then have students fly the drone and try to complete various tasks such as:

- Land in a particular spot on the ground or on a table
- Stay steady at a particular height off the ground
- Travel in a square or circular path
- After they have mastered these tasks individually challenge students to pair up and synchronously perform the above tasks.
- *If time and space allows keep challenging students to synchronously flying the drones in large groups

Bring the class back together at the end and watch the video Biggest Drone Display Ever.

Allow for 5-10 minutes for class reflection, what did students find the hardest about flying the drones by themselves and then synchronously? What do the students find important to remember as they fly the drone?

Part 2: *Students will review the Engineering Design Process and follow the process to modify their drone to drop off a payload at a particular position.*

In the final challenge, students will need to drop off a payload at their decided landing site. The payload delivery may require modifications to the drone. Students will follow the Engineering Design Process for the drone and payload to create preliminary designs of each item.

1. **ASK:** Review the Final Mission objectives for the student (see Mission 11). Then ask the students. What requirements must be met? What are possible constraints? (For educators: What supplies do we have on hand? How much weight can the drone lift? Making a simple payload out of paper is advised unless you have a large drone.)
2. **IMAGINE:** Students brainstorm solutions and research ideas.
3. **PLAN:** Students choose two to three of the best ideas from their brainstormed list and sketch possible designs, ultimately choosing a single design to prototype.
4. **CREATE:** Students build a working model, or prototype, that aligns with design requirements and that is within design constraints.

To complete the final mission, students will need to perform a survey flight, take an image of the map, decide on a landing site, and drop off the payload designed above.

5. **TEST:** Students evaluate the solution through testing; they collect and analyze data; they summarize strengths and weaknesses of their design that were revealed during testing.
    a. Test successful drone flight with payload
    b. Test successful drone survey flight over map, taking one image
    c. Test drone landing and/or payload drop off

Adjustments may be needed to the payload design, camera use of the drone, or other components of the flight. Continue to make modifications in these areas.

6. **IMPROVE:** Based on the results of their tests, students make improvements on their design. They also identify changes they will make and justify their revisions.
    a. Can you identify why the design did not accomplish the Mission Objective?
    b. What type of changes need to be made? Different materials? Sturdier construction?

In their MDL, students should be asked to reflect on the following questions: Although you may have had to improve your design, would your initial design have worked for another type of mission? Were there new challenges flying the drone that you did not experience when first learning to fly the drone? What will you do to continue to improve your drone flight?

Students will finalize designs for drone and payload during the final mission practice sessions.

Mini-Mission 8: Rover Build

Estimated Time: 1 hour

Summary: *Students will work in their group to build their LEGO robot rover.*

Before the mission:

- Download to Software:
  LEGO Spike: SPIKE Prime | Student App Download | LEGO® Education
  LEGO Mindstorm EV3:MINDSTORMS EV3 downloads – LEGO Education
- Go through the Tutorial by clicking on "Start" tab at the top of the window and then "Teacher Preparations"
- Go through each of the "Getting Started" modules to familiarize yourself with the robot and basic programming
- Prepare the kits (if necessary) by adding stickers to the included drawers that show students how to sort the blocks.
- Make sure the robots are fully charged.
- Provide each team with one robot kit.

We recommend you start by having the students build the following rovers:

- *LEGO MindStorm EV3 Instructions:* Have the students click on the "Build" tab at the top of the window and direct them to build the robot called "Driving Base."
- *LEGO Spike Instructions:* Have the students click on the "Build" tab at the top of the window and direct them to build the robot called "Driving Base 1."

These are good first builds that can be modified to fit the challenge. Students can explore other instructions under the "Build" tab for additional ideas on how to modify their robot. The students can modify the rover as much as they like and they are not required to only use LEGO pieces in their design.

Tell students they can modify their robot for the challenge later, after this initial robot is complete. To help students build as a group, tell them to organize themselves and come up with a method to work together.

In their MDLs, students can include an image of their initial robot build, each iteration as they modify it to better complete the final challenge.

Mini-Mission 9: Programming and Robotics

Full Lesson: Unit4 L3 Programming and Robots

Estimated Time: 2 hours

Summary: *Students will begin by thinking about the logic and individual steps involved in everyday tasks. Next, students will begin to create simple programs with their robot. Finally, students will plan the individual steps needed to have their robot navigate the challenge map and create, test, and debug programs to have their robot complete mission objectives.*

Before the mission:

- Have printed or electronic copies of "Process Flow Chart Symbols" for reference
- Make sure the robots are fully charged
- Provide the students access to computers with the LEGO software

Part 1: *Students will individually think about an everyday task and break it down into the smallest steps possible.*

Go over the following example with students:
The task "Go to the adjacent room and bring back a green book" can be broken down into:

1. Walk to door
2. Open door
3. Step through door
4. Walk 100 steps
5. Turn left
6. Walk 500 steps
7. Turn left
8. Observe if door is open or closed
    a. Turn knob and open door
    b. Proceed if already open
9. Step through open doorway
10. Look for bookshelf
11. Walk to bookshelf
12. Identify a green book
13. Grab green book
14. Turn around, reverse steps, etc.

Example flowchart for above task

Have the students write instructions and make a flow chart for the following example: Make a peanut butter & jelly sandwich. (Note: the peanut butter and jelly sandwich prompt can be done in person with real materials if your logistics allow!). Make sure to provide students with the "Example Flowchart" and "Process Flow Chart Symbols" links.

Part 2: *Students will begin to program their robots with basic commands before moving on to complete the final challenge.*

Provide each student or groups of students with a robot and ensure they have the applicable software downloaded for their robot.

Students should work individually or as a group to explore the programming blocks and try to complete the following activities:

1. Robot moves a specific distance forward and stop
2. Robot moves in a complete circle
3. Robot moves in a square path (making 3 turns and stopping at the original position.)
4. Robot avoids an obstacle (use the ultrasonic sensor to detect an object)

For the LEGO robots you can use some of the built in lesson plans to help guide the students through these activities. If you have the LEGO Spike robot, we recommend you have the students click on "Units" then download the "Competition Ready" set of lesson plans. Then they should start with Training Plan 1. For the LEGO EV3 Mindstorm robot we recommend they click on "Units" then "Robot Trainer." Here the "Moves and Turns" and "Grab and Release" lessons are particularly useful. If you think your students need more help, please don't hesitate to request help from NESSP.

Part 3: *Students should first diagram how they would expect a robot to move around the map to complete the Challenge objectives.*

Have the students review the challenge map and ask them.

- What path should the robot follow?
- Where should the robot not go?
- What type of signs might the robot need to use on the map to tell it to change direction or avoid an obstacle?

Students should then create a flowchart as done in the Engage section but this time with the instructions they expect to give their robot before using the programming blocks to navigate the Challenge Map.

Part 4: *Students will formulate programs to complete the final mission.*

Before students start coding for the final mission, you should explain to them how the rover portion of the mission will be scored and provide them with a "sample" to practice retrieving (see the Final Mission Section and the Scoresheet in the Appendix for more information). Students should be encouraged to retrieve one or two samples first and, once that is successful, write a program that can get additional samples. Depending on the design of their rover, students may choose to store more than one sample on board or retrieve and return one sample at a time.

You should encourage what coders call "version control". That means that students should save previous versions of their code, especially if it is working. For example, students might have a program that allows them to retrieve one or two samples. Encourage them to save it with a different filename before modifying it to retrieve additional samples. That way they can revert back to the original code if the new one has problems or if they run out of time to complete it.

Programs should be tested on the map and debugged as issues come up. See "Out of Order Lesson" from LEGO in the resources tab for a full guided activity on debugging.

- Is there a particular program block or sensor that students are having recurring problems with?
- Did the students create a flowchart or plan for their code? Did their initial programming logic work to complete the task correctly?

Here are some ideas for helping debug your code and identify issues:

- Use a display block to show values on the screen
- Use tones/sounds to indicate when a certain point in the program has been reached
- Use the brick lights to indicate the state of the program
- Use a wait block with the brick buttons (or a touch sensor) to "pause" your program at a certain point, then press the button to resume

More debugging ideas can be found in the "Debugging Tips" link.

In their MDL, students should provide sample code with at least one Loop or Switch including comments.

Students will finalize designs for drone and payload during the final mission practice sessions.

Mini-Mission 10: Team Mission Patch

Estimated Time: 1.5 hours

Summary*: Students will examine several mission patches from former NASA missions and try to understand what each mission was about based on the patch. Then, they will learn more about the patches and the missions they represent to help launch their own patch designs.*

Before the mission:

- Prepare to project the mission patch slides
- Have computers available so students can access slides OR print out the reading for each of the patches
- Provide students with materials to make their own mission patch, such as paper, markers (or colored pencils), or computer drawing software

Part 1: *Students will look at some past NASA mission patches.*

Display the first slide of the slides. Ask students to discuss the patches with a partner or group of 4. What do they notice and what do they wonder about the patches?

Give students 10 minutes to discuss the patches in their teams. Then, assign one patch to each student in the group and give them access to the slide for their patch. (NOTE: The readings about the patches are not equal in length.)

Instruct students to read the information on their patch and mission to see if it confirms what they noticed about the patch, as well as any new information that is added. Once all students have had a chance to read about their patch, they should assemble with their group of 4 and take turns sharing information that they learned.

Part 2: *Students will design their mission patch and make any necessary additions to their MDLs.*

Now that you have had a chance to rehearse the mission and review your MDL, create your team's mission patch. Include at least one paragraph explaining that answers the following questions:

- Why did you choose the images and words that you chose?
- How does the design represent the mission?
- How does the design represent the team and/or the team's community?

One possible approach to this task is to allow students to share their patch designs (without the narrative) with other teams, to see if the images and ideas in the patch are clear (similar to what was done in the first part of "Engage" in this lesson).

In their MDLs, *students will include their mission patch and mission patch narrative.*

Final Mission

Summary: *In the final mission students will use their drone to identify a landing site and drop a payload. Next they will use their programmed rovers to autonomously retrieve samples from their map, while avoiding the barriers.*

Before the mission:

- Make sure the rovers and drones are charged
- Prepare to use the scoring sheet in the Appendix (or your own criteria) to evaluate each team's progress
- Estimate how much time you need based on the number of teams in your camp. You may choose to give teams extra time to practice or allow each team to make adjustments and multiple attempts.
- Take pictures or video tape each team's attempt (or have a team member do it) so students can include it in their final presentation and submit it to NESSP.

For their final mission students will complete and be scored on 3 tasks:

1. Drone landing site selection
2. Retrieval of the samples by their rover
3. A 5-8 minute presentation based on their MDL

Each of the components of the final challenge can be worked on during the practice blocks at the end of the week. The final challenge and presentation (along with awards) should be completed on the final day.

Drone Landing Site Selection:

Students will fly their drone over the map and take an image of both landing areas. They will then select a landing location and use the drone to drop the payload in that location. See the scoresheet in the Appendix for details on how to score the final challenge. This component of the mission should be video for reference later and/or so that it can be included in the MDL presentation.

Retrieval of Samples by Rover:

The rover should be started at the landing position selected by the drone. It should then drive around the course, collecting and bringing as many samples as possible back to the landing zone while avoiding the obstacles on the course.

See the scoresheet in the Appendix for details on how to score the final challenge. The rover and drone component of the mission should be video for reference later and/or so that it can be included in the MDL presentation.

MDL Presentation:

Students will use the information in their MDLs to “tell the story” of their mission in a 5-8 minute powerpoint presentation that will be presented to the group at the end of the week.

The presentation should include images and a little text to describe each activity from the week:

- What did the students learn about the surface and interior of Europa?
- The final Yeast ID card and a brief description of the experiment
- The moon they observed and a description of why it looked different under different colored lights
- The challenge map and how they designed it
- Their drone payload and the results of their final challenge
- Their rover and the results of their final challenge
- Their mission patch and why they designed it the way they did

It is up to the instructors to determine how final awards will be distributed or if they will be distributed, but we provide certificates for Top Teams in each category as well as an overall Top Team.

Appendix:

Icy Worlds Reading and Resources:

The ROADS on Icy Worlds Manual includes a short description about Icy Worlds that is useful for mini-mission instructors to read in addition to the students (if it is age-appropriate).

Download the Icy World's manual here (see Appendix A):
https://nwessp.org/challenge/roads-on-icy-worlds/

Or read "Why Icy Worlds" here:
https://nwessp.org/2022/04/27/why-icy-worlds/

Name Tags:

NESSP will provide a name tag template and lanyards for your mini-mission scientists to registered instructors.

Certificate of completion and awards:

If you choose to print award certificates or certificates of completion will be provided to registered instructors.

Final Mission Scoring:

A [Google Spreadsheet]() is provided that will allow you to automatically score the final mission of each team. For each row, teams are awarded 5 points if they successfully completed that portion of the mission and 0 points if they did not complete it. The criteria on the scoring sheet are as follows:

Landing Site Selection/Drone Landing:

- *Take an image of the map with the drone, select the landing site:* Are the students able to use the drone to observe both landing sites and take a picture of the site where they intend to drop their payload?
- *Flight to landing zone demonstrated:* Did the students fly the drone with good enough precision to hover over the landing zone (even if a payload is not successfully dropped)?
- *Payload present on the drone:* Is the drone carrying a payload to be dropped at the landing site?
- *Payload dropped at the landing site:* Did the drone successfully drop and leave the payload at the landing site?
- *Precision of the drop:* The blue circles that represent each landing site can be thought of as a target. If students land in the smallest circle, give them 3 points. Two or one points should be awarded for the larger circles and zero points if the payload is dropped outside of the circles entirely. (Note: These values have to be manually entered into the scoresheet.)
- *Drone returns to base:* Did the students safely fly the drone back to a "base" and safely land it?
- *Drone doesn't crash:* Give the students points if they do not crash their drone during the execution of their mission.

Surface Navigation:

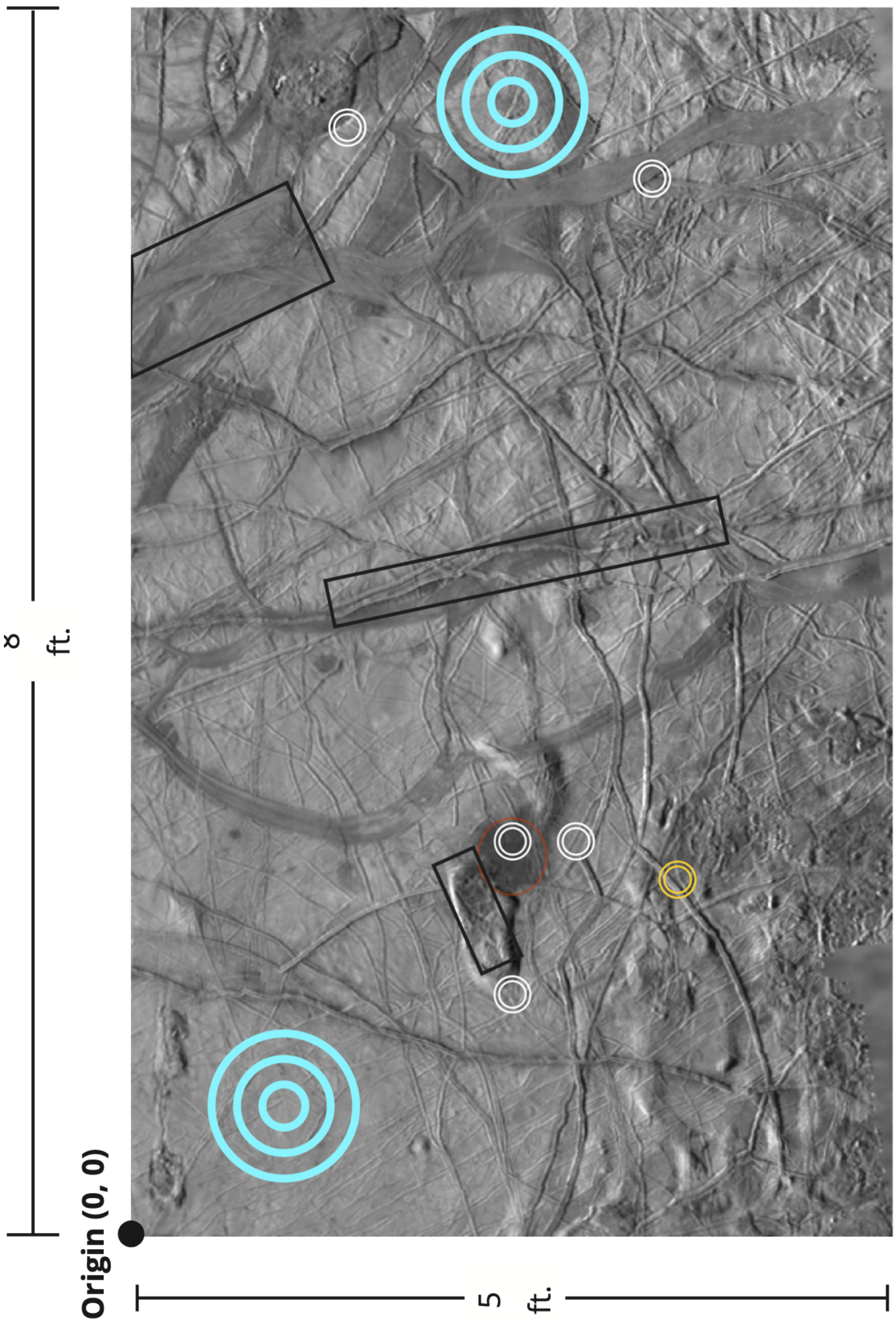
- *Surface navigation demonstrated*: Did the students successfully program the rover to do any of the criteria in the Programming and Robotics block?
- *Rover maneuvers outside of the landing zone:* Did the rover leave the landing zone?
- *Rover did not cross any barriers*: Did the rover avoid the "barrier" regions on the map (black boxes)?

Sample Collection:

- *Sample collected 1-5*: Did the students rover successfully pick up the samples? Note: The 5th sample can be optional and associated with color sensing.
- *Sample 1-5 returned to the landing site*: Did the rover bring back that sample to the landing site? Note the students can bring the samples back one by one or bring them back all at the same time (usually easier).
- *Rover navigates to chaos region:* Does the rover get to the region where the samples are located, even if it does not successfully pick up any samples?
- *Rover takes color reading:* You may want to challenge the students to sense the color of the yellow sample regions. If you choose to do this you can give them points for successfully taking the reading.

Team name:			
Final Mission Scoring			
Scoring directions: each dropdown box in column D should be filled in with "Yes", "No", or "Not being scored." The "Not being scored" selection should be used if a team was unable to attempt that component of the Mission Objective The one exception is MO-06, "Precision of payload drop off." This should be scored 0 - 3 based on the proximity of the payload to the center of the landing zone. O being outside, 3 being within the innermost circle. Column E will populate with point values as the values in column D are filled in.			
Landing site Selection/ Drone Landing			
Take image of map with drone, select landing site			-
Flight to landing zone demonstrated			-
Payload present on drone			-
Payload dropped off at landing site			-
Precision of payload drop off (0 - 3)			-
Drone returns to base for safe shutdown			-
Drone doesn't crash			-
Surface navigation			
Rover swapped out for payload			-
Surface navigation demonstrated			-
Rover maneuvers outside of landing zone			-
Rover does not cross any barriers			-
Sample collection			
Sample 1 collected			-
Sample 2 collected			-
Sample 3 collected			-
Sample 4 collected			-
Sample 5 collected (Optional)			-
Sample 1 returned to landing site			-
Sample 2 returned to landing site			-
Sample 3 returned to landing site			-
Sample 4 returned to landing site			-
Sample 5 returned to landing site (Optional)			-
Rover navigates to chaos region			-
Rover takes color reading (Optional)			-
Final Challenge Total			0

Challenge Map:



Additional Activities:

College Admission and Scholarship Search:

First-generation or underrepresented students in high school often don't understand that there are resources to help them pay for college. For example, many low-income students don't know that many ivy league schools will offer them full tuition scholarships. For high school students, you can have them list the schools they might be interested in attending and then spend some time helping them understand the financial aid offered at that school.

We recommend you start with a video like this one from QuestBridge: https://www.youtube.com/watch?v=KNZndnqRxQs

Next you can hand out the scholarship resources sheet and give students time to explore or take them through a few of the websites to help the students understand the details of that scholarship and the application process. It may be useful to remind students about the deadlines, what type of information they will need, and who at their school can help them.

College Student Panel:

With advanced notice NESSP may be able to set up a virtual panel of college students for your campers to talk to. The students can give perspective on their own unique paths to college and then take questions from the students. This activity can help the students see that there are a variety of ways to become a successful college student. Please email info@nwessp.org if you would like to set up a panel.

STEM Career Exploration:

It can be useful for students (high school students especially) to look at what type of careers are available in the industry they want to pursue. For example, students are often surprised at what type of skills and degrees are requested for applicants to SpaceX or Blue Origin.

Have the students think about what type of career they are interested in and what companies or organizations they would like to work for. Then help them use a browser to navigate the job advertisements of those companies/organizations. Ask individuals or groups of students to report back what job they found most interesting and what type of degree qualified you for that job. They can also report back any other information they found to be interesting or surprising.

Science Matter Expert Presentations:

During the academic year, the ROADS on Icy Worlds Challenge had several Science Matter Expert (SME) presentations and question and answer sessions. Although the students in your mini-mission are not able to interact with these experts live, they still will enjoy watching the presentation and learning more about what scientists and engineers who work on the Europa Clipper mission do. Each presentation is about 45-60 minutes long.

The following SME presentation can be found on YouTube:

Dr. Marshall Styczinski:
"How to study the oceans inside Europa"!
https://www.youtube.com/watch?v=iYmAncywkJY

Mishal Aleem:
Flight Software Engineer at JPL
https://www.youtube.com/watch?v=COCwvYIbLN8

Dr. Britney Schmidt:
https://drive.google.com/file/d/1GoWkFTpkUMsGe0ERxHvdm6GBHUAJ5P3P/view?usp=sharing

Tie-Dying Shirts:

NESSP can provide materials to tie-dye the shirt provided as part of the camp. This fun activity will give the students unique memorabilia of their mini-mission!

We recommend this die kit:
https://www.amazon.com/Tulip-One-Step-Tie-Dye-Kit-Activity/dp/B08XM1W9L2/ref=sr_1_20?crid=RREFQG32HX4K&keywords=galaxy+tie+dye+kit&qid=1651179558&sprefix=galaxy+tie+%2Caps%2C253&sr=8-20

If possible, you should do this activity outside. When campers are done dying the shirts, put them in a large zip-lock back and send them home with the campers to be washed and dried. If the students' parents aren't able to wash and dry the shirts, offer to take a set home to do yourself.

Icy-Worlds Mini-mission Materials List:

MM 1: Communication in Complex Projects

Provided by instructor:	Provided by NESSP
☐ Lego pieces ☐ Paper/pencils for documentation ☐ Cameras (optional)	None

MM 2: Mission Development Log

Provided by instructor:	Provided by NESSP
☐ Access to computers, one per group ☐ OR notebook and pencils to document	None

MM3: Explaining Europa's Surface

Provided by instructor:	Provided by NESSP
☐ Access to computers, one per group or instructor with projection ☐ OR notebook and pencils to document	None

MM4: Map Development

Provided by instructor:	Provided by NESSP
☐ Print out of challenge map ☐ Rulers, one per team ☐ Calculators, one per team ☐ Meter stick or tape measure, one per team ☐ Large-scale paper (or sheets of paper taped together) and art supplies	None

MM5: Limits of Life

Provided by instructor:	Provided by NESSP
☐ Printouts of extremophile cards ☐ Sugar, salt, yeast, vinegar, tums, etc. ☐ Hot water heater and/or ice cubes ☐ Digital camera ☐ Timer	☐ Foldscopes ☐ Beakers/test tubes ☐ Thermometers ☐ Ph Paper ☐ Balloons

MM6: Remote Sensing

Provided by instructor:	Provided by NESSP
☐ Box with holes cut out and covers over holes, one per team ☐ Cameras	☐ Foam half-spheres, on per team ☐ Clay, one per team ☐ Colored lights or filters

MM7: Drone Development and Landing Site Selection

Provided by instructor:	Provided by NESSP
☐ Phone or tablet to run drone app to take picture (optional)	☐ Drone, one per team

MM8/MM9: Rover build/Programming and Robotics

Provided by instructor:	Provided by NESSP
☐ Computers or laptops, one per team ☐ Materials to make sample (can use legos or paper cubes or ping pong balls) ☐ Masking tape for testing, one per group ☐ Rulers for testing, one per group	☐ LEGO Robot (EV3 Mindstorm or Spike) ☐ **Note:** Since this camp involves programming robots, it is essential that teams of students have access to computers or tablets. If this is an issue for your camp, please contact NESSP at info@nwessp.org and we may be able to accommodate.

MM10: Team Mission Patch

Provided by instructor:	Provided by NESSP
☐ Art supplies and paper ☐ OR easy to use graphic design program ☐ Digital camera	None

Additional Supplies provided by NESSP:

- ☐ Lanyards, one per student
- ☐ Tie-Dye Supplies, one per ~10 students
- ☐ T-shirts, one per student
- ☐ Name tag and Certificate Templates

Drone Safety Information:

When you're flying a drone, you are technically flying a type of aircraft. The FAA (the U.S.'s Federal Aviation Administration) considers a drone to be an unmanned aircraft system, or UAS, and has rules covering how to properly use them.

Any team member who will take a turn flying the drone, and all of the team's Mission Advisors, should spend some time reviewing the FAA's information on drone flying. Specifically, look at the FAA's sections on recreational flyers and on educational users (educational use is a subset of recreational use, so both are important). There's quite a lot of information available from the FAA, so we'll link you directly to the relevant sections:

FAA website — Recreational flyers: https://www.faa.gov/uas/recreational_fliers/
FAA website — Educational users: https://www.faa.gov/uas/educational_users/

Drone Safety Tips:

The following tips are a quick introduction to drone safety. These do not cover everything you need to know about safely flying a drone! **Please** take the time to review the FAA information linked to above.

- Know the controls — Review and understand your drone's controls before you begin. Be especially aware of how your drone's emergency stop function works.
- Check the weather — Don't fly in wind, rain, or other bad weather. Even if you're flying indoors, check for drafts from heating/cooling systems.
- Keep your eyes on the drone — You should always be aware of where the drone is. Don't fly it out of your own line of sight or your observer's line of sight.
- Be a safe pilot — Make sure you feel ready to pilot before you turn on your drone. Don't fly if you're feeling unwell. And if you have long hair, by all means tie it back!
- Scout the area — Be aware of other people in the flying area as well as any large objects or other drones. Always fly your drone so that you don't hit anyone or anything.
- Be airspace smart — The FAA closely controls the U.S.'s airspace. Use the FAA's B4UFLY mobile app to check your proposed flying zone to be sure it's okay to fly there. And always fly below 400 feet in Class G (uncontrolled) airspace.