Artemis ROADS II

2023–2024
National NASA Student Challenge

www.nwessp.org

Official Manual English

October 2023

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About NESSP

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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Department of Physics
400 E. University Way
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We want to see NESSP in action!

Share vides or photos of your experience.

Facebook and Instagram: @nwessp

Find information videos, tutorials and recordings of live-streamed events at:

https://www.youtube.com/nwessp

Partner

Disclaimer statement:

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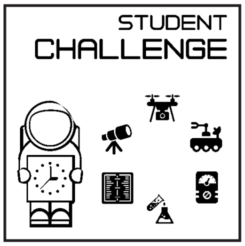
About ROADS

Our ROADS program (Rover Observation And Discoveries in Space) is a framework that allows students to explore STEM concepts through hands-on activities. ROADS takes inspiration from real NASA projects and guides students on space-related missions. Each year, we update ROADS to address different science and engineering problems and to visit various solar system bodies. For the 2023–2024 challenge, we have developed eight Mission Objectives inspired by the NASA Artemis program! Teams document their progress in completing the Mission Objectives in a Mission Development Log and submit their materials to NESSP for team recognition (see Page 4-5).



About the ROADS Challenge

The Artemis ROADS II Challenge is an excellent team activity suitable for in-class group projects, school robotics, programming, or other club activities, as well as Scout troops and other community organizations. Find more information about the ROADS Challenge, including the support available for qualified teams and informational videos, on the Challenge website: https://nwessp.org/challenge/artemis-roads-ii/

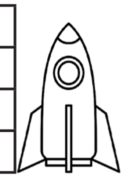
Mission Advisors & Challenge Team Information

The **Mission Advisor** is the adult who will be guiding the team. This person could be a classroom teacher, the advisor for an extracurricular club, a Scout leader, or any responsible adult from the community. It's the Mission Advisor's responsibility to manage all communications between NESSP and the team, including team registration and submitting results. Teams may have up to two Mission Advisors.

A **Challenge Team** is a group of 3 to 6 students, in grades 3–12, who will be working together to complete the challenge. Team members must be enrolled in primary or secondary school or be under the age of 18 at the time of registration to participate. Teams with students from multiple grades should complete the Mission Objective "Deliverables" of the highest grade level within the team. Mission Advisors can register and mentor more than one team. Team members within a challenge team can be updated, changed or consolidated teams (as needed) up until the Mission Objective's submission date.

Challenge Teams are classified into one of three categories based on the age of their oldest team member at team registration.*

Category	Maximum Age
Pegasus	11 years old
Crawler	14 years old
Astrovan	18 years old



*Teams that are consolidated are subject to be reclassified by NESSP based on the age of their oldest team member at team consolidation.

How to Register

Mission Advisors must register a Challenge Team to be eligible for supply loans and the team recognition described on Page 4. You can register your team on our website at the following link: https://nwessp.org/artemis-roads-ii-registration-form/. The deadline to register is January 17th, 2024.

How to Complete The Mission

Once a team is registered for the challenge their Mission Advisor should submit their team's results for each of the following stages so that the team's work can be recognized.

Submit results at:
https://nwessp.org/artemis-roads-ii-submissions/

Challenge Stages:

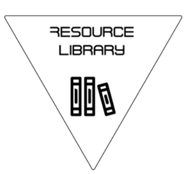
Stage	Submission	Recognition	Deadline
Lift Off	Register as a Mission Advisor by providing your name and contact information, and information on your organization.	Team Challenge Supply Loan* and Artemis ROADS II Stickers and we will put your "team" on our National Challenge Map! *For qualified teams.	Wednesday January 17, 2024 5:00 pm PST
Injection Burn	Submit student team member names and information and an image of the teams Mission Patch (MO-2).	Teams receive a package from NESSP with stickers and other NASA-themed educational content.	Wednesday, January 31, 2024 5:00 pm PST
Lunar Flyby	Submit photos of the team's work for 3 additional MOs. Teams attending an in-person final challenge must register.	Teams can apply for travel support to attend a final Hub challenge event. Teams attending final events receive team recognition packages.	Wednesday, March 15, 2024 5:00 pm PST
Re-Entry	Mission Advisor submits the team's Final Mission Development Log.	Teams receive a Certificate of Completion Teams that submit their Final Challenge Virtually receive a recognition package. Teams are invited to the Meet an Astronaut virtual event. Each team that completes all MOs receives one entry into the NASA Center drawing.* *Only team members that are at least 12 years of age in the Crawler or Astrovan categories are eligible to attend the NASA Center trip.	Wednesday, June 5, 2024 5:00 pm PST

ROADS Challenge School-Year Schedule

Team Registration Opens	10/4/2023
Information Sessions (various dates)	10/01/2023-01/08/2024
Registration Closes (Lift Off)	**01/17/2024**
Mission Advisor Support Session 1	02/01/2024
Meet a NASA Expert	02/13-02/17/2024
Injection Burn Initial Submission	01/31/2024
Mission Advisor Support 2	03/01/2024
Meet a NASA Expert	03/13-03/17/2024
Lunar Flyby Submission and Final Challenge Event Registration Deadline	**03/15/2024**
In-Personal Final Challenge Events (MO-8a)	04/01-06/02/2024
Mission Advisor Support Session 3	05/05/2024
Re-Entry Final Submission Deadline	**06/05/2024**
Virtual Meet An Astronaut	06/05-06/31/2024
Kennedy Trip Window	TBD

In-person Final Challenge Events

Student teams have the option to complete MO-08 either in person at a regional Final Challenge event or at home. Teams who complete MO-08 at home should submit their results virtually by 06/05/2024. Further information regarding the dates, locations, and times of Final Challenge Events will be available in early 2024.



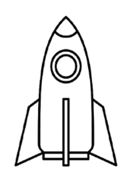
Additional Support

Additional resources for teams including links to information on NASA science, instructional videos, NESSP "Office Hours" schedule, and information on how to request a TA can be found on the NESSP's website: https://nwessp.org/challenge/artemis-roads-ii/

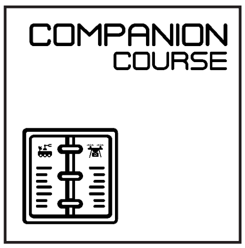
Program Evaluation

Mission Advisors will be contacted by Horizon Research Inc. after registering for the challenge and will be asked to complete a short survey before and after the challenge.

Participation in these surveys helps NESSP improve the quality and outcomes of its programs and enables NESSP to continue receiving support from the NASA Science Activation Program. Mission Advisors can also email the evaluators at NESSPeval@horizon-research.com if they have not received an email or have additional questions.



About the ROADS Companion Course



The Companion Course, consisting of classroom-ready lessons, is designed to support each ROADS challenge. The Artemis ROADS II Companion Course centers around the guiding question: 'How can we use experiments, models, and rehearsals on Earth to understand other solar system objects and plan a successful mission to the Moon?' It comprises 11 lessons within 4 units, each following the '5E' instructional model and aligning with middle and high school Next Generation Science Standards (NGSS).

Most Companion Course lessons align with the Mission Objectives (MOs) of the Artemis ROADS II Challenge (see the next page). While teams are not obligated to complete any part of the Companion Course as a Challenge requirement, many Mission Advisors find these additional resources valuable for extending or supplementing the learning associated with the Mission Objectives. Educators can learn more about the Artemis ROADS II Companion Course at:

https://nwessp.org/course/artemis-roads-ii-companion-course/

Local and Cultural Relevance Marker

NESSP strives to create educational content that is meaningful for all communities. The "Local and Cultural Relevance" label in our Mission Objective and Companion Course indicates an opportunity to incorporate the student's connection to their home and culture into their learning.

Companion Course Classroom Supply Loans

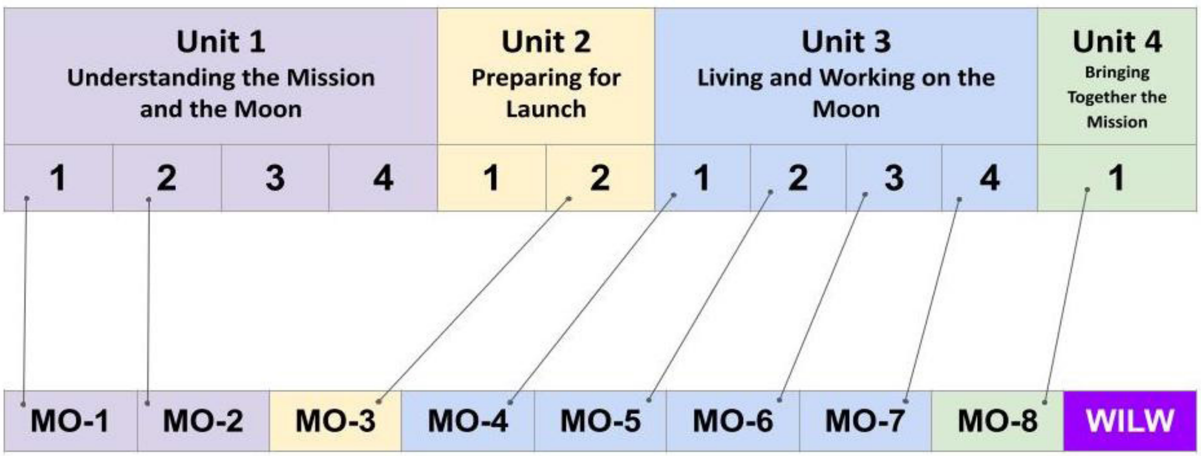
Educators who have participated in a ROADS professional development workshop during the past three years can request classroom-sized supply loans for up to 2-months to help them implement the Companion Course lessons in the classroom. Educators must register for Companion Course Classroom supply loans by November 10th and can receive kits between October 4th, 2023 and May 30th, 2024. All materials on a 2-month loan must be returned to NESSP by June 15th, 2024.

To request classroom supplies, sign-up for the Companion Course by filling the form at: https://nwessp.org/artemis-roads-ii-companion-course-sign-up/

If you're interested in borrowing materials for your classroom from NESSP but haven't attended a professional development workshop, please follow us on social media (@nwessp) or subscribe to our newsletter from our website (www.nwessp.org) to learn about furture professional development opportunities..

Challenge Mission Objectives & Relevant Companion Course Lessons

Alignment of Companion Course Lessons and Challenge Mission Objectives:



UNIT & LESSON	MISSION OBJECTIVE (MO)
Unit 1: Understanding the Mission and the Moon **L1:** Introducing the Mission	**MO-01:** Mission Development Log (MDL)
Unit 1: Understanding the Mission and the Moon **L2:** Building a Strong Project Team	**MO-02:** Mission Patch
Unit 2: Preparing for Launch **L2:** Getting to the Moon	**MO-03:** Getting to the Moon
Unit 3: Living and Working on the Moon **L2:** Building Habitats on the Moon	**MO-04:** Building Habitats on the Moon
Unit 3: Living and Working on the Moon **L2:** Gardening on the Moon	**MO-05:** Gardening on the Moon
Unit 3: Living and Working on the Moon **L3:** Studying the Earth from the Moon	**MO-06:** Observing the Earth from Moon
Unit 3: Living and Working on the Moon **L4:** ROV-ing on the Moon	**MO-07:** ROV-ing on the Moon
Unit 4: Bringing the Mission Together **L1:** Presenting and Reflecting on the Mission	**MO-08a:** Complete the Mission at a Final Challenge Event!
	MO-08b: Complete the Mission by Submitting Results Online!

ROADS Challenge Mission Objective Overview

MO-1: Mission Development Log
A Mission Development Log is the record of your mission, beginning to end. Document your plans, findings, failures, and successes. Each member should contribute!

MO-2: Mission Patch
A mission patch is an important symbol of any NASA mission, reflecting the team, the object of study, the spacecraft, the mission goals, or a combination! How will you represent your Artemis ROADS mission and crew with imagery?

MO-3: Getting to the Moon
A safe, powerful rocket will take Artemis astronauts to the Moon. But before NASA gets that far, they test prototypes hundreds or even thousands of times! For this mission objective, you will make and test at least two different rocket designs.

MO-4: Building Habitats on the Moon
When you go on a long journey, you can't always bring everything with you. This is why NASA is looking for ways to build a habitat on the Moon using mostly lunar materials. Teams will research different habitats and design, build, and test their own scale model structure that can protect astronauts from the harsh conditions at the south pole of the Moon.

MO-5: Gardening on the Moon
Living and working on the Moon will require things like eating and breathing on the Moon! Plants can help with both of these life requirements, but only if we can figure out how to grow them in barren Moon soil or in hydroponic (water only) systems.

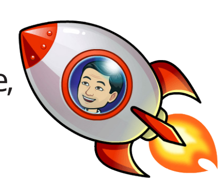
MO-6: Observing the Earth from Moon
Humans on Earth have been observing the Moon since time immemorial and creating scientific and cultural explanations of what they see. What will astronauts on the Moon see when they look back at the Earth? What scientific and cultural stories will they create?

MO-7: ROV-ing on the Moon
Humans aren't the only ones who will be working on the moon–robotic rovers will be there before us and working alongside human crews. How will your ROV assist the astronauts? Your team will demonstrate that it can design, build, and program a supply delivery rover in the Mission Objective.

MO-8a: Complete the Mission at a Final Challenge Event!
IT'S GO TIME! Your team has modeled and tested its mission, and now it's time to launch. Teams who choose to go to an in-person Final Challenge Event will present their MDL to the judges and use what they have learned to complete their mission live on the Final Challenge Course.

MO-8b: Complete the Mission by Submitting Results Online!
Teams who cannot make it to a Final Challenge Event will complete their final mission on their own printed or homemade courses and submit their MDL and a video of their Final Mission on the NESSP website.

WILW: Wing it Like Winglee
As NESSP's founding director, Dr. Winglee, might remind us, sometimes you gotta wing it! Describe something you tried for Artemis ROADS II that didn't go as expected. What happened, what did you learn, and what happened next?



MISSION OBJECTIVE

MO-01 : Mission Development Log

Astronaut Sunita Williams participated in the journals investigation. Crew members agreed to journal at least three times per week either by typing on a laptop or recording audio files. (Credits: NASA) She uses a laptop to chronicle her time on the ISS. Astronauts used to have to use pen and paper to keep track of their mission, which is why NASA developed a special pen that could write in zero gravity during the Apollo missions. (Source: NASA)

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 1 Lesson 1: Introducing the Mission

I. Summary

A Mission Development Log is the record of your mission, beginning to end. Document your planning discussions, your plans, findings, failures, and successes. Each member should contribute!

II. Mission Guidance

The Mission Development Log (or MDL for short) documents a team's scientific investigations, initial and final engineering designs, successes, and failures. Yes — successes AND failures! Scientists and engineers rarely get it right the first time. Changes occur as more information becomes available, and getting it wrong provides a wealth of information on how to successfully proceed — in other words, it is okay to fail. Even though the final product should be designed so that these failures no longer occur, it's normal to make mistakes and to fail as you learn how to get to that final successful product.

MO-01 : Mission Development Log *continued*

II. Mission Guidance *continued*

Documentation and evidence of your work can take many forms! Of course, this will include some written work. In addition, we would expect to see labeled sketches, diagrams, data tables, calculations, descriptions, bulleted lists, photos, and/or video clips. The specific type of documentation will depend on the deliverables for each Mission Objective, so be sure that you are clear on what each Mission Objective requires!

An MDL template has been provided in Google Slides format, as well as instructions on modifying the template in multiple formats. You will designate a lead student for documenting each MO, but ALL team members should participate in compiling the MDL and students should take turns being the lead documentarian.

III. Deliverables

At the end of the challenge, teams will submit a PDF of their MDL during the submission window from May 1st, 2024 to June 5th, 2024 on the submission page on NESSP's website (https://nwessp.org/artemis-roads-ii-submissions/).

The MDL should:

- ☐ Have a title slide with team name, team number, team members's names, and the mission patch (see Template)
- ☐ Include a completed Table of Contents slide (see Template)
- ☐ Include the deliverables for each completed MO
- ☐ Be 50 slides or less (including 9 blue MO direction slides, see Template)

IV. Resources

- Companion Course Unit 1 Lesson 1: Introducing the Mission
- MDL Template

MO-02 : Make a Mission Patch

I. Summary

A mission patch is an important symbol of any NASA mission, reflecting the team, the object of study, the spacecraft, the mission goals, or a combination! Teams will design and make a mission patch that represents them, their community, and their Artemis mission.

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 1 Lesson 2: Building a Strong Project Team

II. Mission Guidance

A good mission patch represents the team's objectives and community values. Examples on this page include both NASA missions and mission patches from previous ROADS teams!

Teams are encouraged to get creative and design a mission patch representing themselves, their community, and their mission in the Artemis ROADS II Challenge. The Companion Course has resources that can help teams identify and incorporate images and text that are relevant to both the mission and to themselves and their community. Use the format (drawing, computer graphic, hand-crafted) that works best for you.

Local and Cultural Relevance	Looking for inspiration based on your local culture or traditions? Check out this Padlet of local and traditional art forms! https://padlet.com/parrar2/inspiringart

What size should your patch be?

- For a hand-drawn or other hand-crafted mission patch, please submit a clear photograph of the patch in jpg or png format.
- For a computer-generated mission patch, your graphic should be no smaller than 500 x 500 pixels.

III. Deliverables

In their MDL, teams should:

☐ Include an image of the patch

☐ Describe the mission patch with at least one paragraph, addressing the following questions:

- What is your team's name and why did you choose it?
- 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?

IV. Resources

- Materials List
- Companion Course Lesson, Unit 1, Lesson 2: Buiding a Strong Project Team
- NASA's E-Clips: Our World - Mission Patches

MISSION OBJECTIVE

MO-03 : Getting to the Moon

I. Summary

A safe, powerful rocket will take Artemis astronauts to the Moon. Before each launch, NASA tests prototypes hundreds or even thousands of times! For this mission objective, you will make and test at least two different rocket designs.

II. Mission Guidance

Teams will design and build a rocket to fly to and from the Moon. First, teams should use the linked resources to understand what makes a successful rocket, including identifying the center of pressure and the center of gravity. Teams may also use the guide that shows them how to employ free simulation software to test their rocket design ideas before constructing their rocket.

Next, teams will build their rockets! Students should use everyday materials like 2-liter water bottles, cardboard or foam board, plastic, and balsa wood. Teams should create at least two rockets that are the same in every way except for one important design variable. Teams may choose to test/change:

- Changes in the rocket body length or width
- Different nozzle designs
- Different fin or nose cone designs
- The density, temperature, or gas content of the liquid fuel

Safety is NASA's first core value, along with integrity, teamwork, excellence, and inclusion. NASA's commitment to safety helps it succeed despite taking on incredible challenges. Before launch, each team must consider safety. Sometimes that means that NASA needs to delay a launch or a mission (meaning it's a no-go), just like it did for the Artemis I launch.

Before launching the rocket, teams must develop a checklist describing safety procedures and protocols that must be a "go" before the launch. Teams will appoint a safety officer to ensure each item on the list is a go before launch. Examples may include verifying that the fins are adequately attached or providing a clear launch site.

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 2, Lesson 2: Getting to the Moon

MO-03 : Getting to the Moon *continued*

II. Mission Guidance *continued*

If the launch is a go....blast off! Students should analyze each flight. They can measure the altitude and characterize the stability of the rocket. They should also consider the following questions:

- What went well?
- What could be improved?
- Did we catch something important before the launch?
- Is there a checklist item that needs to be changed?
- How might we change our rocket before flying again?

The Artemis I launch of NASA's SLS rocket on Nov. 16, 2022. (Credit: NASA)

III. Deliverables

In their MDL, all grades must:

☐ Describe and include images of at least two different rocket designs.

☐ Include their safety checklist, procedures, and protocols.

☐ Analyze rocket flights. In particular, teams should describe how many times they flew each rocket design and compare and contrast the performance of the designs.

MO-03 : Getting to the Moon *continued*

III. Deliverables *continued*

	In their MDL, grades 3-5 must: • Use qualitative analysis to determine the best rocket design. Teams can consider variables such as stability, height of flight, and sturdiness of their rocket. In their MDL, grades 6-12 must: • Employ quantitative and qualitative analysis methods to determine the best rocket design.Teams can consider variables such as flight time and maximum altitude (using an altitude tracker), stability, and sturdiness of their rocket. • Include a statistical analysis (e.g., averages) of the multiple flights of each rocket design. In their MDL, grades 9-12 must: • Include a table or graph to present data from multiple flights of each rocket.

IV. Resources

- Materials List
- Companion Course Unit 2 Lesson 2: Getting to the Moon
- Water Rocket Launcher Directions | NASA
- Video on how to use Aquapod Launcher
- Flight of a Water Rocket

MO-04 : Building Habitats on the Moon

I. Summary

When you go on a long journey, you can't always bring everything with you. This is why NASA is looking for ways to build a habitat on the Moon using mostly lunar materials. Teams will research different habitats and design, build, and test their own scale model structure that can protect astronauts from the harsh conditions at the south pole of the Moon.

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- [Unit 3, Lesson 1: Building Habitats on the Moon]

II. Mission Guidance

First, teams should consider what living and working spaces would be needed for a lunar mission with four astronauts lasting one month. How are these spaces different from where they live now? Teams can be inspired by structures on Earth. They may also want to investigate living conditions on the International Space Station.

Teams should use materials sturdy enough to withstand the lunar environment and provide thermal protection for astronauts. They should conduct tests on regolith samples (or regolith-like materials such as sand or flour) to evaluate their properties, including strength, drying time, shrinkage, and thermal insulation. These tests should be completed before finalizing the habitat design, enabling the teams to utilize the results for improvements.

For instance, teams may design a test to compare the strength of two different recipes and choose the strongest one for their final structure. The MDL should contain a description of each test, its results, and their ultimate design.

Local and Cultural Relevance	One thing that NASA hopes to do is use locally available resources on the Moon to build the habitats. The document linked below shows examples of how humans have done this in various locations on Earth. Have teams review this document (and conduct additional research if they'd like) to get ideas on how they might use lunar resources to construct their Moon base. A2 U3L1 Building Techniques & Materials

Next, the teams will design their Moon habitat, considering the astronauts' needs and the properties of regolith materials. The MDL must feature a detailed diagram of the habitat, indicating each room with clear labels and providing full-scale dimensions using the metric system.

MO-04 : Building Habitats on the Moon *continued*

II. Mission Guidance *continued*

After creating the diagram, teams should construct a scale model of their habitat. Various methods are possible, including using a pastry bag with homemade “lunar” concrete or other hard-drying material (like icing), a 3D printer, a 3D pen, cardboard, or other common craft materials, or a combination of these techniques. For example, teams might 3D print a frame for their lunar habitat or components like doors, walls, or windows and then fill or reinforce the walls with a concrete-like material.

III. Deliverables

In their MDL, all grades must:

- ☐ Describe the recipes used for the regolith testing, the tests performed, and the results of those tests (including at least two photographs). Additionally, identify which recipe worked best and explain the reasons for its success
- ☐ Include a labeled design drawing of the Moon habitat and an explanation of why it was designed that way, including how the design was inspired by the Earth structures explored.
- ☐ Provide three photos and details about the construction methods for the three-dimensional scale model of the Moon habitat.

Grade Level Adaptation	In their MDL, grades 6-12 must: • Describe the details of the scale factor you used in the model. • Describe the total square footage of the proposed lunar habitat, the square footage per person, how it compares to the structures researched and modern homes, and whether that amount of space is sufficient.

IV. Resources

- Materials List
- Companion Course Unit 3 Lesson 1: Building Habitats on the Moon
- A2 U3L1 Building Techniques & Materials

MO-05 : Gardening on the Moon

Scientists from the University of Florida examine an experiment that compares plants grown in lunar soil from the Apollo missions to plants grown in Earth soil. (Credits: UF/IFAS photo by Tyler Jones)

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 3, Lesson 2 Gardening on the Moon

I. Summary

Living and working on the Moon will require things like eating and breathing on the Moon! Plants can help with both of these life requirements, but only if we can figure out how to grow them in barren Moon soil or in hydroponic (water only) systems.

II. Mission Guidance

In this Mission Objective, students are tasked with designing and conducting an investigation focused on plant growing conditions. Students should design an experiment where they change one factor that they think might affect the growth of the plants, what they choose to change is called the independent variable. They can choose from the following example investigations or create their own:

- Compare plant growth between an untreated local soil sample and a sterilized one using heat (baked/microwaved/pressure cooker/solar heat).
- Compare plants grown hydroponically in distilled water only with plants grown in water enhanced with fertilizers.
- Compare the growth of plants exposed to continuous lighting with those exposed to varying lighting durations (e.g., 12 hours of light and 12 hours of darkness).

In their experiments, students must keep all factors not being tested the same (such as water, light, temperature, type of seed, etc.), these factors are referred to as controlled variables. The teams will measure various aspects of plant growth (the dependent variables), such as days to germination, number of leaves, stem length, etc., and then compare the results between the two (or more) conditions they are investigating.

MO-05 : Gardening on the Moon *continued*

II. Mission Guidance *continued*

Local and Cultural Relevance	Looking for inspiration based on your local culture or traditions? Check out this list of suggested seeds to use in the experiment or do some research to discover locally relevant seeds in your area. Example Seed Choices

III. Deliverables

In their MDL, all grades must:

- ☐ Describe the experiment by drawing or taking a picture of the experiment set-up and identifying the independent, dependent, and controlled variables.
- ☐ Describe the frequency of measurements and when measurements were taken.
- ☐ Include at least three photographs of their experiment in progress. Photos should be dated and labeled with a description of what they show.
- ☐ Include the experimental data in table or graphical form.
- ☐ Describe the results including a comparison of the plant growth for the two (or more) experimental conditions.

IV. Resources

- Materials List
- Companion Course Unit 3, Lesson 2: Gardening on the Moon
- Scaffolding Students to Plan and Carrying Out Investigations
- Scientists Grow Plants in Lunar Soil | NASA
- Example Seed Choices

MO-06 : Observing the Earth from the Moon

I. Summary

Humans on Earth have been observing the Moon since time immemorial and creating scientific and cultural explanations of what they see. What will astronauts on the Moon see when they look back at the Earth? What scientific and cultural stories will they create?

II. Mission Guidance

When observing the Moon from Earth, the most apparent pattern is the changing Moon phases. For astronauts living and working on the Moon, they will observe similar phases of the Earth. They will also see the features of Earth change over short and long time periods. This mission objective explores the causes of these changes in relation to Earth's four systems.

Students will select a change to Earth's surface or atmosphere that could be observed from the Moon, imagine what it would look like, and describe their findings in their MDL. This could be any grade-appropriate phenomena (weather, climate, ocean currents, jet stream, water cycle, weathering and erosion, extreme weather, plate tectonics, etc) happening on a variety of time scales from near-instantaneous changes (like landslides) to geologic time scales (like plate tectonics) or anything in between (like hurricanes).

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 3, Lesson 3: Studying the Earth from the Moon

Local and Cultural Relevance

Imagine that people have been living on the Moon for a very long period of time. They understand the science of the changes they observe on Earth, but still like creating stories or calendars to describe and explain what they see. Get creative and craft a story or make a calendar that Moon-dwellers might use to explain the changes observed.

Image of the Earth from the Apollo 8 mission. (Credit: NASA, Earthrise 1)

MO-06 : Observing the Earth from the Moon *continued*

III. Deliverables

In their MDL, all grades must:

- ☐ Describe the change in the selected Earth system as observed from the Moon, including what caused the change, and what was affected (cause and effect).
- ☐ Describe or draw what the change would look like from the Moon.
- ☐ Describe the time scale of your change. How quickly or slowly would astronauts notice it? Feel free to include a series of labeled drawings or a comic strip with your explanation.

	In their MDL, grades 3-5 must:
	• Include a story or calendar that Moon-dwellers might create to explain the Earth System change you described. Be creative!
	
	In their MDL, grades 6-12 must:
	• Choose one of the following Sun/Earth/Moon system questions and provide a claim with evidence about your answer to the question. Responses can be essays with labeled diagrams, videos that show a model or diagram, or a combination.
	  ◦ How big will the Earth look from the Moon? How big will the Sun look from the Moon?
	  ◦ How fast and in which direction will the Earth move across the sky when viewed by astronauts from the Moon?
	  ◦ Predict how often people on the Moon will see the same spot on the Earth (for example, your hometown). Does the frequency change or stay the same?
	  ◦ Is there any place on Earth that you won't be able to see from the Moon?
	  ◦ Does the Earth appear to have phases from the Moon? If so, describe them and the pattern they take.

IV. Resources

- Companion Course Unit 1, Lesson 3 (Background Information)
- Companion Course Unit 1, Lesson 4 (Background Information)
- Companion Course Unit 3, Lesson 3: Studying the Earth from the Moon

MO-07 : ROV-ing on the Moon

I. Summary

Humans aren't the only ones who will be working on the Moon--robotic rovers will be there before us and working alongside human crews. How will your ROV assist the astronauts? Your team will demonstrate that it can design, build, and program a supply delivery rover in the Mission Objective.

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 3 Lesson 4: ROV-ing on the Moon

II. Mission Guidance

In MO-3, teams built a rocket to deliver transport payloads TO the Moon; now, teams must consider how to transport tools, equipment, and people ON the Moon. Let's face it! Driving on the Moon is hazardous, so it's better to use a special rover that can move things between habitats without human help.

Before teams start building their rover, they will need to download software for their rover and take some time to get familiar with the robot, sensors, and how to program it. If team members are new to programming or using the NESSP LEGO robots, there are extra resources available in the Companion Course lesson or the resource section to help teams get started.

The primary function of the rover is to transport packages (Lego cubes) between various habitats within the Moon colony. The robot will depart from the main habitat's storage area, pick up a package, and travel to a designated drop-off location (target on the map). Upon delivering the package, the robot will return to the storage area, ready for another assignment.

How will the robot navigate to its destinations? It relies on a color-based system. Each package has a unique color, such as blue or green, indicating its specific destination. At our lunar station:

- red packages must be taken to the Observatory,
- green packages are sent to the Earth Communication Outpost,
- yellow packages to the Launch Complex, and
- blue packages to the Crater Ice Research Station.

The robot must be programmed to automatically detect the color of the package it's carrying, enabling it to determine its appropriate delivery location.

To figure out how to program your rover, we suggest the following steps:

- Draw a smaller version of a map with a coordinate system. Include an origin point and mark the main habitat and other habitats where the rover will deliver supplies. Mark any dangerous areas on the map that the rover should avoid.
- Use the map to plan the route your rover will follow and draw the path it will take.

MO-07 : ROV-ing on the Moon *continued*

II. Mission Guidance *continued*

- Make measurements using a ruler and a protractor to determine how the rover will drive on the big map.
- Write down the steps (called pseudo code) the rover should take if it senses each possible color of payload in its storage area. This will help you later when you need to program these actions.

Once teams have figured out and written down the steps their rover needs to take, it's time to start building, programming, and testing them. In particular, they should:

- Learn the basics about how to program the rover to sense color, move straight, and turn.
- Design and build a rover to accurately drive the designated paths, carry packages, and drop them as close to the center of the target as possible.
- Try out one set of commands or steps at a time, just like NASA engineers do.

It's possible that the rover won't behave exactly as expected. That's okay! As a team, students should make changes to the design of their rover and adjust the details of their code until the rover successfully completes its mission.

Next, it is time to see how well you can handle new challenges. What if something unexpected happens on the Moon, like an emergency with an astronaut? Your rover might need to drive to a different location to help out quickly. Teams participating in an in-person hub event might face even more new tasks to test how flexible and adaptable they are. This means you'll have to think on your feet and develop new strategies when faced with unexpected situations. Teams can practice driving to surprise locations before they come to the final event.

III. Deliverables

In their MDL, all grades must:

☐ Include a picture or drawing of the rover, labeling important components.

☐ Describe the path their rover travels by drawing a coordinate system in their MDL that includes an origin (0,0) point and ticks or a grid measured in centimeters. Students should then identify the location of the home base and each supply drop location on their coordinate system. Finally students should draw the path they programmed for their rover.

MO-07 : ROV-ing on the Moon *continued*

III. Deliverables *continued*

 	In their MDL, grades 6-12 must: • Use “MyBlock” (Word Blocks) or a function (Python) in their program one or more commands that are repeated multiple times, • Use the coordinate system to find out how far the rover needs to travel for each package delivery and scale up these distances to see how much farther your rover would travel on the real lunar surface. • Calculate the number of trips a real lunar rover could complete without needing to recharge. Assume it has a range of 20 km on a single battery charge. In their MDL, grades 9-12 must: • Include a flowchart that describes the code they wrote for the challenge (see the Extend portion of Companion Course Unit 3 Lesson 4 for resources on flowcharts).

IV. Resources

- Materials List
- Artemis ROADS II Final Rover Challenge Map
- Artemis ROADS II Surface Navigation Phase Elementary School Student Handout
- Artemis ROADS II Surface Navigation Phase Middle School Student Handout
- Artemis ROADS II Surface Navigation Phase High School Student Handout
- Sample Square Cutouts (packages) for Artemis ROADS II
- Companion Course Unit 3 Lesson 4: ROV-ing on the Moon
- Launch Into Math – Exercise 8: Coordinate Planes

MO-8a : Complete the Mission at a Final Challenge Event!

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 4 Lesson 1: Presenting and Reflecting on the Mission

Summary

IT'S GO TIME! Your team has modeled and tested its mission, and now it's time to launch. Teams who choose to go to an in-person Final Challenge Event will present their MDL to the judges and use what they have learned to complete their mission live on the Final Challenge Course.

Mission Guidance for Teams Attending In-Person Events

Teams planning on attending an in-person hub event will complete Mission Objective 8 at the final event location.

The final mission for all age ranges will involve the following phases:

- **Launch Phase:** Teams will launch their most successful water bottle rocket design. The rockets will be evaluated based on maximum altitude, flight stability, design creativity, and durability. Multiple launches may be required if time permits.
- **Surface Navigation Phase:** Teams will demonstrate their supply delivery rover on the challenge map. NESSP will load the rover with a supply to be delivered. The rover will sense the supply's color to determine the delivery location and attempt to deliver it accurately to the target in the payload bay. Afterward, NESSP will load the rover with another supply, and teams must deliver at least four payloads.

  Teams with a red package in their rover's supply bay (middle and high school divisions) will be challenged to send their rover to a surprise location. They'll receive the surprise delivery location at the start of the final challenge event and need to program the rover to drive there on-site. Practice and testing of code can be done on the practice course during the challenge event.
- **Mission Readiness Review (MDL Presentation):** The Mission Readiness Review presentation will be a concise summary of the team's MDL. Presentations should be 8 minutes or less and cover the following, depending on completed Mission Objectives:
  - Mission patch and why they designed it the way they did (Mission Objective 2)
  - A description of their Moon base habitat (Mission Objective 4)
  - Evidence of successful plant growth (Mission Objective 5)
  - Visuals depicting what the Earth looks like from the Moon (Mission Objective 6)

MO-8a : Complete the Mission at a Final Challenge Event! *continued*

Mission Guidance for Teams Attending In-Person Events *continued*

- **Surprise Challenge:** Artemis astronauts must collaborate, develop new strategies, and master new skills for their Moon missions. In-person events will include surprise challenges to test teamwork and engineering abilities specific to lunar work.

How to prepare?

To get ready, teams should create and practice a Mission Readiness Review presentation based on their MDL. Additionally, they need to bring a water bottle rocket ready for launch using a standard launcher provided by NESSP. Lastly, teams should bring the rover they designed and programmed for the surface navigation phase of the final challenge. Additional details will be provided by the host depending on the specific activities at each Final Challenge Event.

What's next?
Submit a Mission Development Log by the June 5th, 2024 deadline.

Teams completing Mission Objective 8 at a Final Challenge event still need to submit their Mission Development Log and an image of their mission patch image NESSP's website (https://nwessp.org/artemis-roads-ii-submissions/) between May 1st and June 5th, 2024. By doing so, they become eligible for NASA Center trips, a Certificate of Completion, and other recognitions.

The MDL submitted must:

- ☐ Have a title slide that includes the team name, team number, names of team members, and the mission patch
- ☐ Include a completed Table of Contents slide
- ☐ Include the deliverables for each completed Mission Objective
- ☐ Be 50 slides or less (including 9 blue Mission Objective direction slides, see Template in Mission Objective 1)

Good luck!

MO-8b : Complete the Mission by Submitting Results Online!

Summary

IT'S GO TIME! Your team has modeled and tested its mission, and now it's time to launch. Teams who cannot make it to a Final Challenge Event will complete their final mission on their own printed or homemade courses and submit their MDL and a video of their Final Mission on the NESSP website.

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 4 Lesson 1: Presenting and Reflecting on the Mission

Mission Guidance for Teams Submitting Final Results Virtually

Teams submitting virtually will submit a video that shows the team completing the Launch Phase, Surface Navigation Phase, and Mission Readiness Review of Mission Objective 8!

A virtual Mission Objective-8 submission for all age divisions will involve the following phases:

- **Virtual Launch Phase:** Team videos should show the final launch of the team rocket. The video should also include a description of the rocket's altitude and stability. Students should briefly describe their rocket and do a post-flight analysis of the re-usability of the rocket

- **Virtual Surface Navigation Phase:** Team videos must demonstrate their rover delivering payloads on a homemade (or printed) final challenge map. Mission Advisors should load the rover with a supply to be delivered, and the rover must use color sensing to determine the delivery location. The rover should then deliver the payload as accurately as possible to the target in the station's payload bay and return to the main habitat payload bay. The video must show the rover delivering at least four payloads, one to each station. The final submission video does not need to include or describe the code, instead this information should be clearly documented in the team's MDL.

- **Virtual Mission Readiness Review (MDL Presentations):** The Mission Readiness Review presentation will be a 5-minute summary of the team's MDL results. Virtual teams may showcase:
  - Mission patch and why they designed it the way they did (Mission Objective 2)
  - A description of their Mission Objective on base habitat (Mission Objective 4)
  - Evidence of successful plant growth (Mission Objective 5)
  - Visuals depicting what the Earth looks like from the Moon on (Mission Objective 6)

  Teams should use the provided MDL template for guidance on the presentation content.

MO-8b : Complete the Mission by Submitting Results Online! *continued*

Guidelines for teams making a virtual final submission

Virtual teams upload or provide a link to their Mission Objective 8 video at the same time they submit their final Mission Development Log (MDL) and mission patch.

The uploaded Mission Objective 8 video must:

- ☐ Be a single video file or a link to a YouTube video
- ☐ Be less than 10 minutes long
- ☐ Only show the faces of students who have complete the NASA Media Release Form (see MDL template)

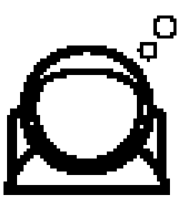
The MDL submitted must:

- ☐ Have a title slide that includes the team name, team number, names of team members, and the mission patch
- ☐ Include a completed Table of Contents slide
- ☐ Include the deliverables for each completed Mission Objective
- ☐ Be 50 slides or less (including 9 blue Mission Objective direction slides, see Template in Mission Objective 1)

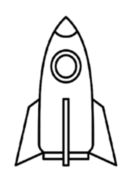
Virtual teams must submit their Mission Objective 8 video and the MDL by June 5th, 2024 to be eligible for the NASA Center trips, a Certificate of Completion, and other recognitions.

Teams submit the MDL and videos at:

https://nwessp.org/artemis-roads-ii-submissions/



Best of luck!



Optional: Wing it Like Winglee

As NESSP's founding director, Dr. Winglee, might remind us, sometimes you got to wing it! Describe something you tried for Artemis ROADS II that didn't go as expected. What happened, what did you learn, and what happened next?

As a rocket scientist, Dr. Winglee was well-known to embody the saying "Stand back! I'm about to do science!" For the "Wing It Like Winglee" Challenge, describe something that didn't go as planned — or even something that went horribly wrong!

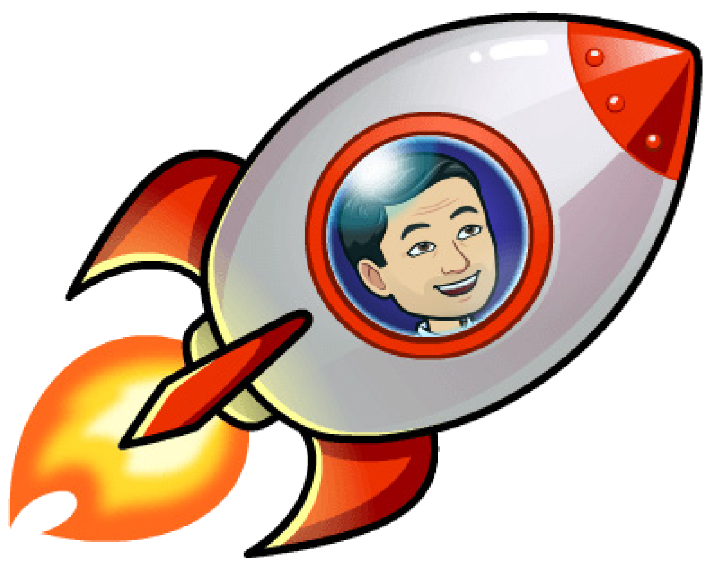
Explain:

- What happened?
- What did you learn from it?
- What did your team do next?

Your entry for this optional objective can be a write-up, photos, a video, or a combination of all three that shows/describes what happened.

Make sure you let us know which part of the challenge you were working on when you had to "wing it!"

You can upload your "Wing it like Winglee" moment anytime at a dedicated submission form on the NESSP website: https://nwessp.org/wing-it-like-winglee-submissions/



APPENDIX: What is the Artemis program?

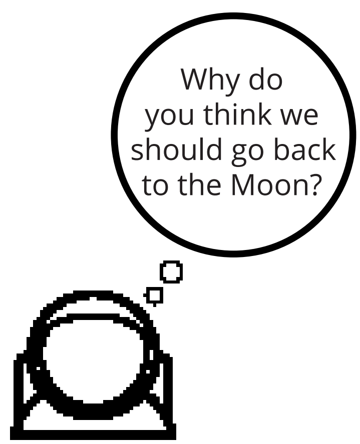
The Artemis Missions are NASA's exciting plans to send humans back to the Moon! They have an amazing team of astronauts, including engineers, biologists, geologists, oceanographers, physicists, pilots, and doctors. Among them will be the first woman and first person of color to set foot on the Moon. NASA wants to learn more about the Moon's environment and improve their spaceflight abilities through robotic and human-crewed missions. By the end of the Artemis missions, NASA hopes to have a community of astronauts living and working on the Moon.

Meet the Artemis Teams: https://www.youtube.com/watch?v=BC5khqpKovU

An artist rendition of astronauts working at a lunar station on the Moon. (Credit: NASA)

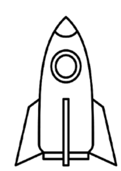
Why go back to the Moon?

So, why go back to the Moon? NASA has three main reasons:



1. To develop new technologies and skills needed for future explorations, like crewed missions to Mars. It's like learning to ride a bike in your own neighborhood before going to a friend's house across town.

2. To study the Moon and learn about the origin and history of Earth, the Moon, and the solar system. The Moon can tell us things we can't learn from studying Earth because its surface has remained mostly the same for billions of years.



3. To inspire a new generation and encourage careers in science, technology, engineering, and math (STEM). Just like

the first Moon landing in 1969 inspired many people to pursue STEM careers, NASA wants to inspire you and others!

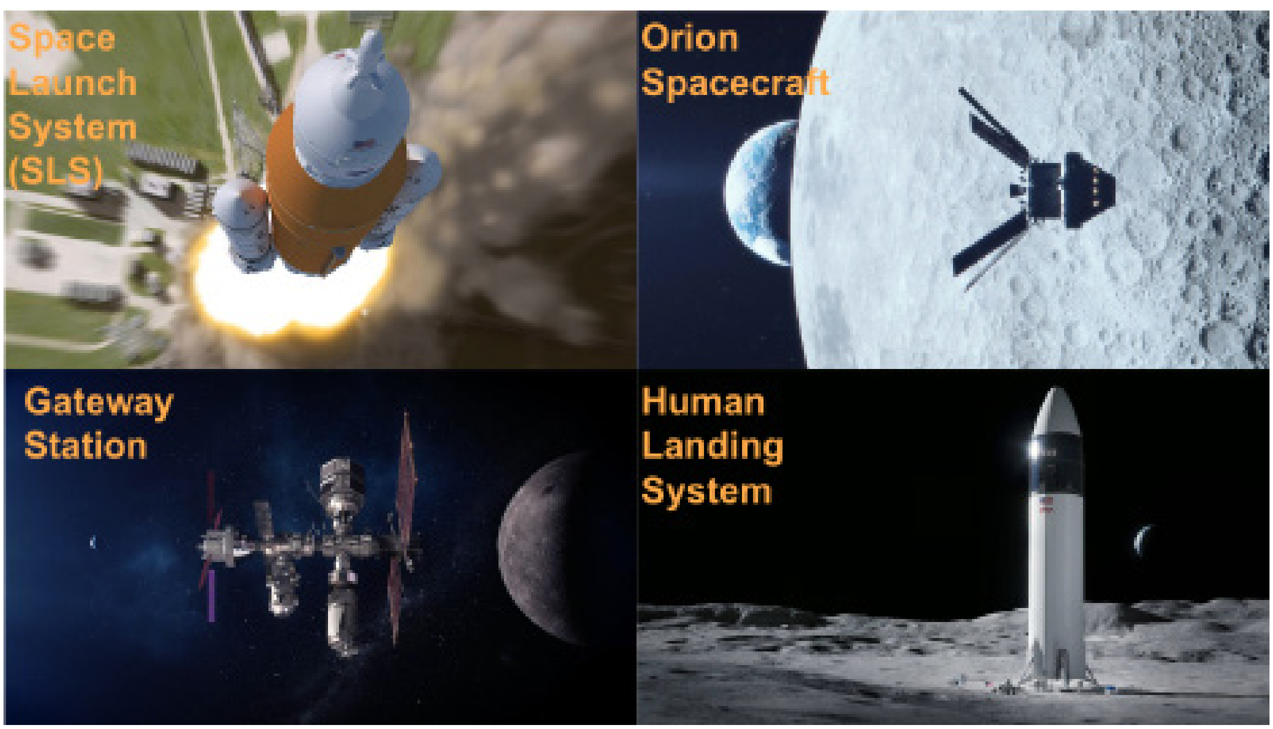
Learn more about why NASA is going to the Moon:

[Why the Moon?]

How will we get there?

A lot has changed since the last time humans went to the moon! The journey to the Moon will involve new methods and technologies to support larger crews, longer visits, and eventually, living on the Moon. NASA and its partners are currently working on some exciting projects:

The Space Launch System (SLS) Rocket: The SLS rocket is designed to be adaptable and powerful enough to take astronauts to the Moon and even Mars. It reaches a speed of 24,500 miles per hour to get to the Moon. The rocket consists of two separate rockets attached to a central core stage, and the astronauts ride on top, just like the Saturn V rocket from the Apollo missions.



Elements of the Artemis Mission. (Top Left) Artist illustration of the SLS rocket leaving the launch pad. (Top Right) Illustration of the solar-powered Orion Crew Module at the Moon. (Bottom Left) Illustration of the Gateway Station at the Moon with the Orion Capsule docked. (Bottom Right) Illustration of SpaceX's Starship Human Landing System on the surface of the Moon. (Credit: NASA)

The Orion Spacecraft: The astronauts will travel to the Moon and back in the Orion Spacecraft. It has different modules, including the Support Module, which keeps the astronauts alive with necessary systems, fuel for navigation, and solar panels for power. The Escape Module allows the astronauts to get away from the SLS rocket if there's a problem during launch. The Crew Module is designed to accommodate four astronauts and is more spacious on the inside than the Command Module used in the Apollo mission. When the Crew Module returns to Earth, it uses a heat shield to enter the atmosphere and giant parachutes to land safely in the ocean.

The Gateway: The Gateway will be a hub in lunar orbit where astronauts transfer from the Crew Module to a lunar lander. It can also store the supplies needed to build and sustain a community on the Moon and serve as a future outpost for missions to Mars and beyond.

Human Landing System: For getting humans to the Moon's surface, NASA selected SpaceX to develop a Starship that can land astronauts on the Moon. The Starship is designed to be more robust than the Lunar Module used in the Apollo missions. Astronauts can reach the Moon directly from Earth without docking with the Gateway.

Artemis Base Camp: In the future, NASA plans to send teams of astronauts to live and work on the Moon for longer periods. They are designing habitats, space suits, and lunar vehicles to make this possible. Experiments on the International Space Station and on Earth are helping astronauts learn how to grow food in space. Robotic missions like VIPER will search for water and help scientists understand the Moon's environment. Subsequent uncrewed missions will land the supplies needed to set up camp.

Learn more about how we are getting to the Moon:

How we are going to the Moon?

Artemis I, II, and III: Phasing In the Mission

NASA is phasing in the mission through a series of missions to test new technology, navigation, safety protocols, and procedures.

Artemis I: The uncrewed mission took place in late 2022, launching in November and successfully orbiting the Moon before splashing down in early December. The goals of this mission were to test the SLS rocket and the Orion Capsule's performance in flight and landing on Earth. Despite some challenges, it was a success.

Artemis II: This will be a 10-day crewed flight that won't land on the Moon but will navigate the planned trajectory for future missions. The crew was announced in April 2023, and the mission is scheduled for November 2024. It will travel far from Earth to test the capabilities of the Crew Module and deep space communication.

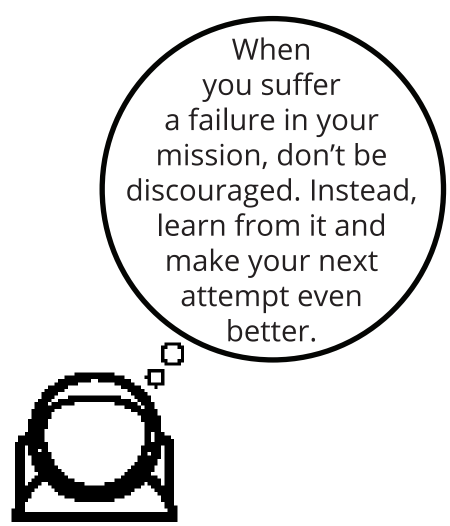
Artemis III: This mission will take astronauts to the Moon. It will be the first time humans have set foot on the lunar surface since Apollo 17 in 1972. The crew will be selected from a diverse astronaut class. NASA has chosen the SpaceX Starship Human Landing System for the lunar landing.

Future missions will continue to develop the Gateway and the Artemis Base Camp until humans can live and work on the Moon for extended periods.

Meet the Artemis II Crew: https://www.youtube.com/watch?v=lPyl6d2FJGw&t=92s

Artemis I: What Went Wrong Before it Went Right?

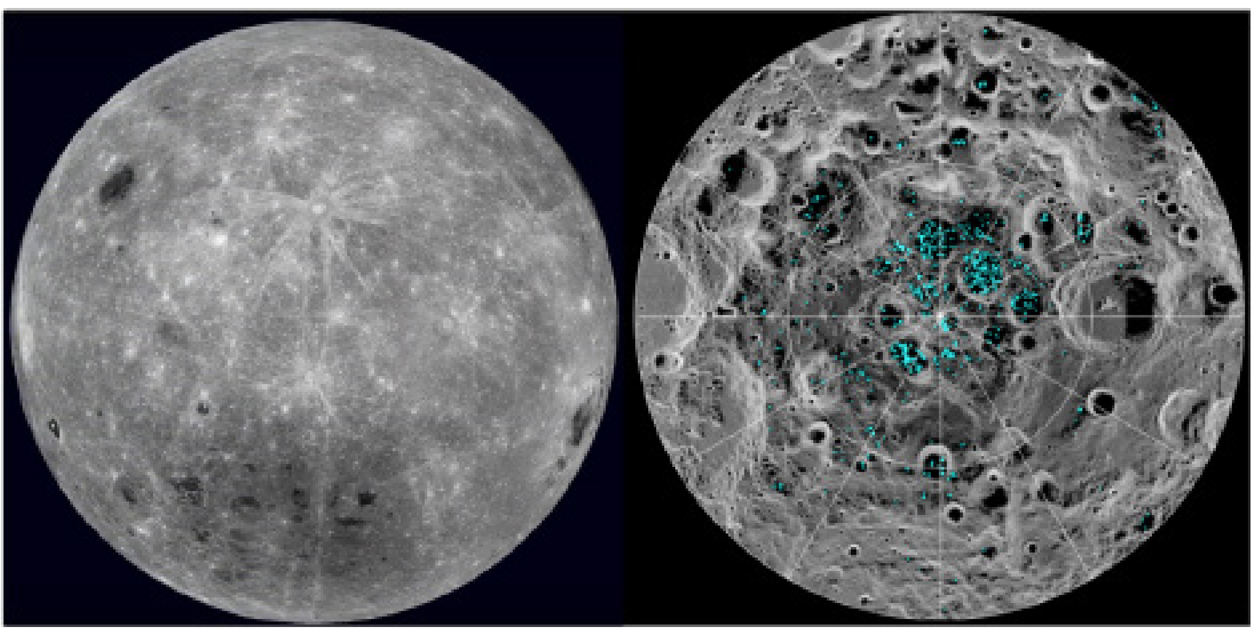
In late 2022, the Artemis I mission launched for its 25-day mission to orbit the Moon. Though it didn't carry a human crew, it was a crucial first step toward returning humans to the Moon. However, success didn't come on the first or even the second try. Engineers and scientists faced hundreds or even thousands of failures before the one shining success of Artemis I. Such huge and complex problems involve years of design, testing, and refinement. Failures, big and small, are part of the process, providing valuable data to improve designs and procedures. This improvement process is called "iteration" and is essential in engineering.



The Artemis team encountered several public problems with the SLS rocket system, leading to multiple launch delays. From November 2020 to November 2022, they faced issues like malfunctioning valves, leaks, and computer failures. Some problems occurred during testing and rehearsal, but the first real "failure to launch" happened on August 29, 2022, when one of the four rocket engines overheated and other issues led to a launch cancellation. NASA attempted again in early September 2022, but a fuel leak in a supply hose caused another scrub. The next launch was scheduled for later that month but had to be canceled due to poor weather conditions caused by Hurricane Nicole. However, the SLS remained undamaged.

Finally, the Artemis I mission was ready for another launch attempt. This time, everything was set, and the SLS rocket successfully launched on November 16, 2022. Can you imagine how frustrating it must have been for the Artemis team to face all these challenges and delays, especially after working on the project for years or even decades?

Where Will We Live and Work on the Moon?



(Left) The far side of the Moon. (Right) An image of the south pole of the Moon. Blue dots indicate where a NASA's Moon Mineralogy Mapper onboard India's Chandrayaan-1 spacecraft detected water ice. (Credit: NASA)

The Moon is the closest neighbor to Earth, about 238,855 miles (394,500 km) away. But it's not very comfortable for humans. The Moon's size is only about a quarter of Earth's size, and its gravity is much weaker, only 16% of Earth's. That's why it can't hold onto an atmosphere, making it an "airless" place. Because of this, the temperature on the Moon's surface goes from a freezing -400 degrees Fahrenheit (-250 degrees Celsius) to a scorching 250 degrees Fahrenheit (120 degrees Celsius) during its long days (which are a bit over 28 Earth days long). The surface is covered with a gray powder called lunar regolith due to billions of years of impacts.

Artemis III will set up a base on the South Pole of the Moon. The Sun is low in the sky there, and long shadows cover the area. This makes it perfect for collecting ice, which can be turned into water for drinking and fuel for rockets. The rims of craters on the South Pole are mostly lit by the Sun, so astronauts can avoid extreme cold during the lunar night, and solar panels can gather energy.

Learn more about the Moon:

[Overview | Inside & Out – Moon: NASA Science]

Or take a video tour of the Moon:

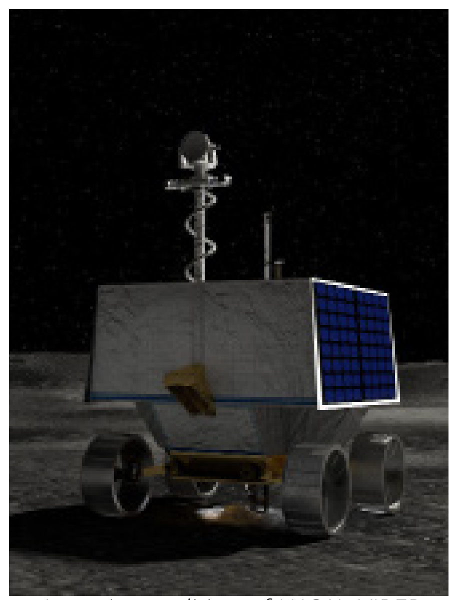
[NASA | Tour of the Moon]

What robotic missions will help us prepare to go to the Moon?

Before and during Artemis missions I, II, and III, several robotic missions will go to the Moon to help NASA prepare for human landings.

NASA's Volatiles Investigating Polar Exploration Rover (VIPER)

This rover, about the size of a golf cart, will study the lunar soil. It will explore the permanently shadowed regions at the South Pole to find out how much water is there.



An artist rendition of NASA's VIPER rover. (Credit: NASA)

Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) CubeSat

CAPSTONE is a small satellite like a microwave in size. It will travel to the Moon to test NASA's navigation models for the Gateway's orbit, which has never been tried before.

Power and Propulsion Element (PPE) and Habitation and Logistics Outpost (HALO)

These are essential parts of the Gateway and will be sent to the Moon first. PPE has solar panels to power the outpost and a propulsion system for navigation. HALO is a pressurized capsule where astronauts can live and work.

Take a tour of VIPER's south pole landing site:

https://youtu.be/bd7ekqMrHkg

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