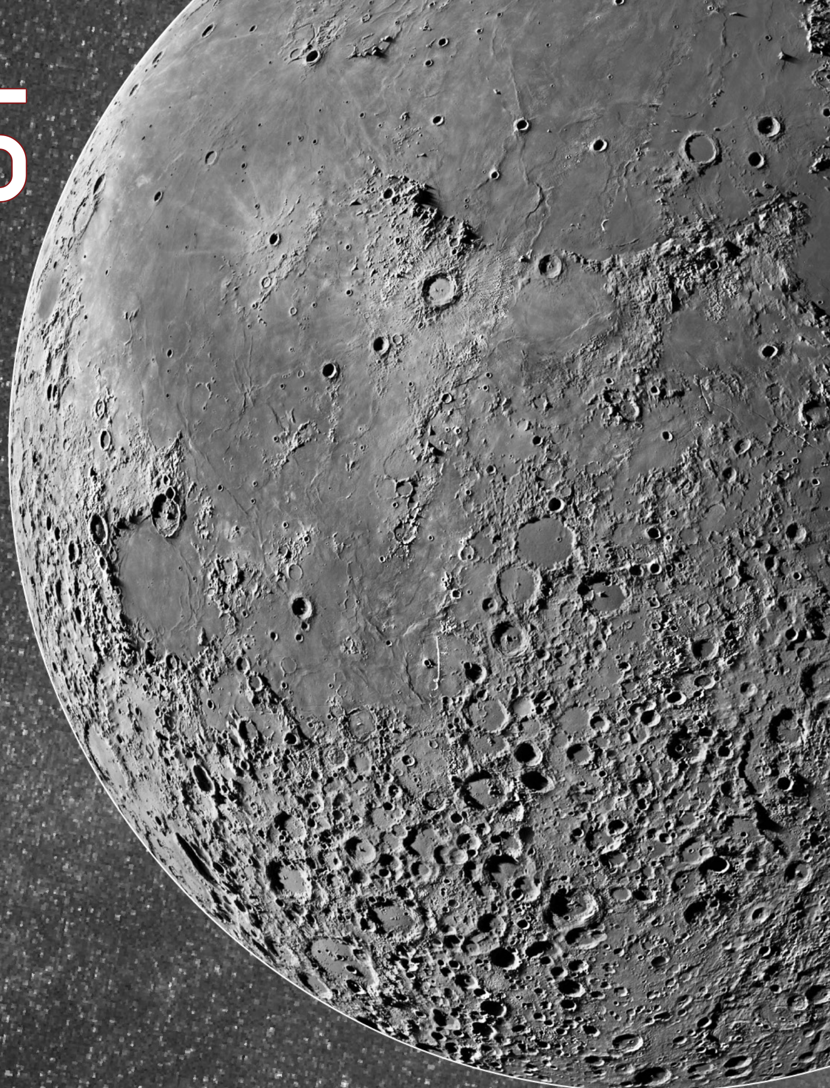
ARTEMIS ROADS



2022–2023 National NASA Student Challenge

Official Manual
English

nwessp.org

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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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We want to see NESSP in action!
Share vides or photos of your experience.
Facebook and Instagram: @nwessp

Find tutorials and recordings of live-streamed events at:
https://www.youtube.com/nwessp

NASA Partner

Disclaimer statement:

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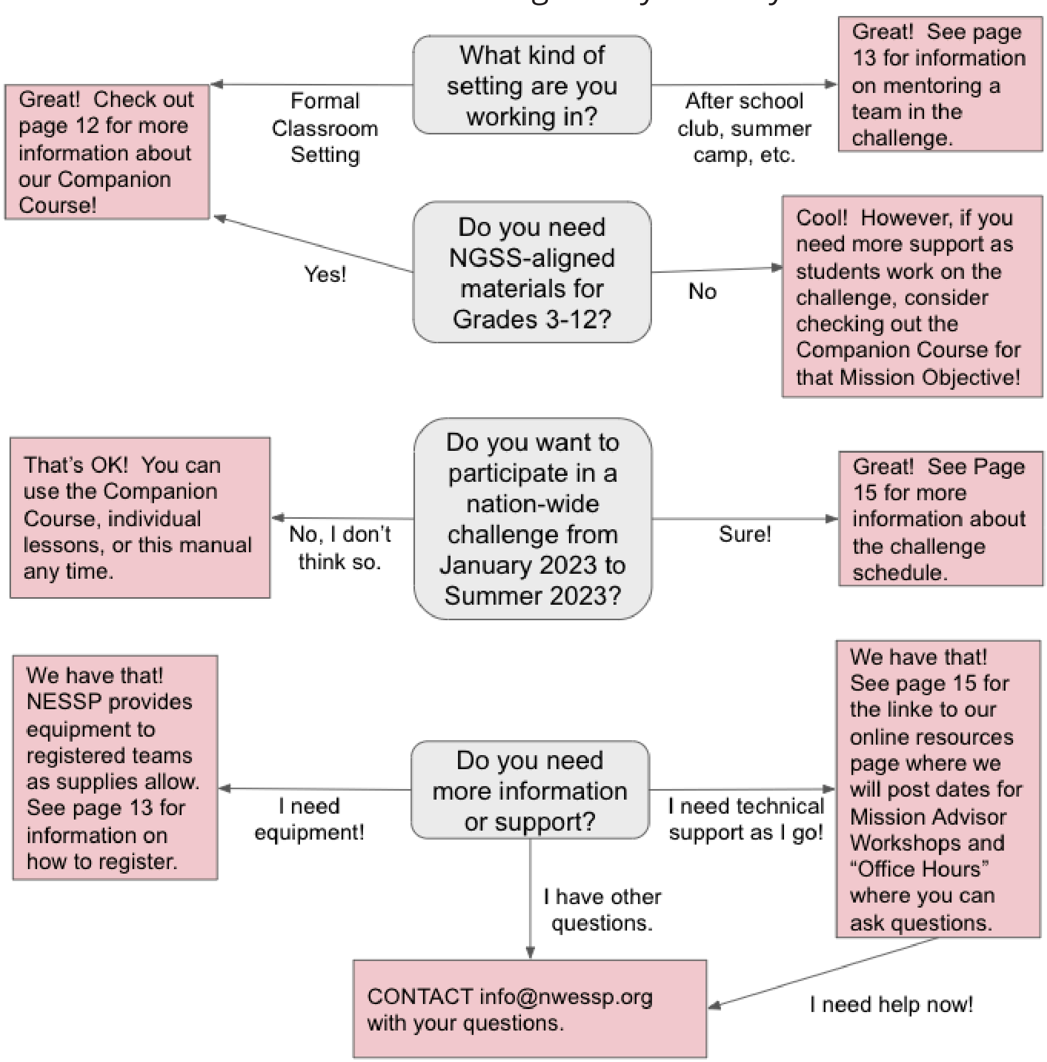
ABOUT ROADS

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 2022–2023 we're going back to the Moon with NASA's Artemis program!

ROADS has two components — the national student challenge and a companion course. You can do just the challenge, just the companion course, or a little bit of both in a choose your own adventure.

You can learn more about each component in later pages, but here's a flowchart to help you choose what sort of adventure is right for you and your students.



WHAT IS THE ARTEMIS PROGRAM?

The Artemis missions will take humans back to the Moon! The astronauts preparing for the missions are 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. Thousands more scientists and engineers will never leave Earth, but are making the missions possible through their work. NASA will learn about conditions on the Moon and increase its spaceflight abilities with a series of robotic and human-crewed missions. By the end of the Artemis missions, NASA will have built a community of astronauts living and working on the Moon.

Meet the Artemis Teams: https://www.nasa.gov/specials/artemis-team/

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

WHY GO BACK TO THE MOON?

NASA has three main reasons for going to the Moon:

1) To develop new technologies, capabilities, and business approaches needed for future exploration, including crewed missions to Mars.

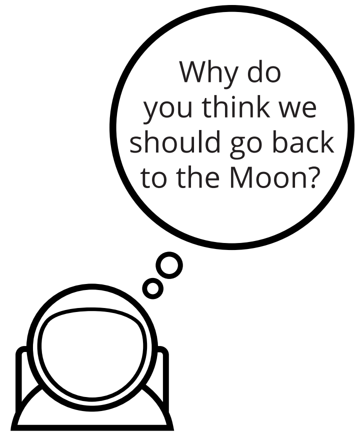
When you learned to ride a bike, did you practice in your driveway or on your street first? NASA uses the same idea to keep astronauts safe. Missions to the Moon are shorter, cheaper, and safer than missions to Mars. After NASA learns how to travel to and live on the Moon, we will be ready to visit Mars!

2) To study the Moon to learn more about the origin and history of Earth, the Moon, and our solar system.

If you make a footprint on a beach, will it still be there in a week? Probably not! The surface of the Earth is changed by water, wind, and life. The Moon has no liquid water or windy atmosphere. We can study things that happened long ago because the surface of the Moon doesn't change as fast as the surface of the Earth. The Moon can tell us things about the solar system that we can't learn from studying the Earth.

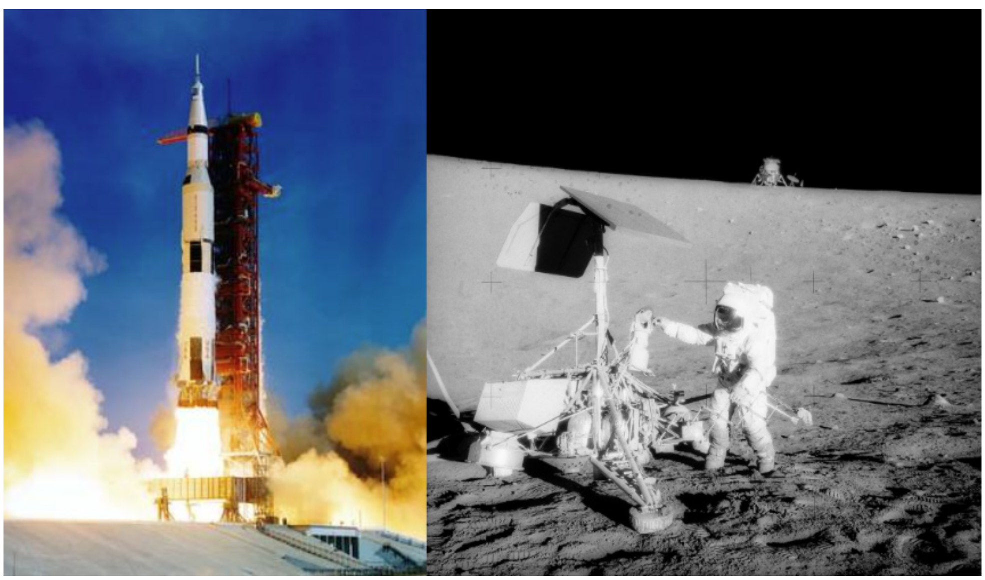
3) To inspire a new generation and encourage careers in STEM.

In 1969, NASA astronaut Neil Armstrong became the first person to walk on the Moon. If you have family members who were alive then, ask them where they were and how they felt at that moment. Watching Apollo inspired people everywhere. Now NASA hopes that Artemis will inspire a new generation, including you!



Learn more about why NASA is going to the Moon:
[Why the Moon?]

WHAT WAS THE APOLLO PROGRAM?



(Left) The powerful Saturn V rocket lifting-off. (Right) An Apollo 12 astronaut reunites with the uncrewed Surveyor 3 spacecraft which landed more than 2 years before. The lunar module can be seen in the distance. (Credit: NASA)

NASA has been to the Moon before. In 1961 President John Kennedy set a goal to put humans on the Moon by 1970. NASA succeeded when Neil Armstrong stepped onto the surface of the Moon in July of 1969 during the Apollo 11 mission.

Twelve astronauts have walked on the Moon during six Apollo missions. During the final three missions, astronauts even drove on the Moon in a rover. Astronauts brought back 842 pounds (382 kilograms) of Moon rock. Studying these rocks allowed scientists to determine the age of the Moon and how it formed.

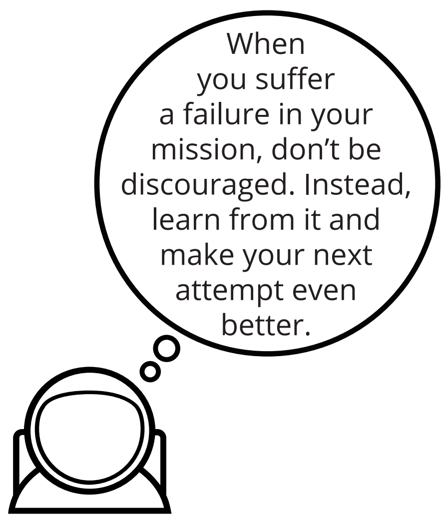
Each crewed Apollo mission to the Moon had three astronauts. They traveled to the Moon in a Command Module. This was a rounded capsule that was only 3 meters (about 10 feet) wide! A Lunar Module took two of the astronauts to the surface of the Moon. The Command Module with one astronaut orbited the Moon until the Lunar Module returned. Then the Lunar Module was left in space, and the astronauts and Command Module traveled back to Earth and used parachutes to land in the ocean.


Astronaut Deke Slayton shows off a prototype of the new filter to other members of mission control. (Credit: NASA)

The astronauts, spacecraft, and tools were launched on top of a powerful Saturn V (pronounced “Saturn five”) rocket. The Saturn V rocket consisted of three parts (called stages). Stages were ignited one at a time and broke away after burning all of their fuel. This reduced the rocket’s mass so that the rocket could go faster.

NASA tested the elements of the Apollo mission on Earth first. Astronauts practiced flying in simulators, got used to their spacesuits, and took field trips to test equipment. Then, the Saturn V rocket was used for two uncrewed flights (Apollo 4 and Apollo 6). The first crewed mission was Apollo 8. Apollo 8 orbited the Moon, but didn’t land. Apollo 10 tested the Lunar Module in space.

NASA and its astronauts had some serious problems during the Apollo program. During Apollo 13, a spark caused an oxygen tank to explode. The damage forced the crew to abandon their plans to land on the Moon. Their new mission was to make it back to Earth alive. The Apollo 13 astronauts worked with scientists and engineers on the Earth to solve many complex problems. For example, carbon dioxide needed to be removed from the air, but the round filters for the Command Module didn’t fit in the Lunar Module’s square holes. On Earth, this would be a simple problem to fix. However, the astronauts could only use the tools and materials that they already had with them. Engineers on the ground worked quickly to design a solution with plastic bags, cardboard, and duct tape. The engineers had to relay instructions on how to build their device using words alone, because no pictures or diagrams could be sent to the spacecraft. Amazingly, it worked! The astronauts safely returned to Earth.



The scientists and engineers used what they learned from each failure to improve the next mission. NASA proved it had the ability to solve problems, even on a spacecraft almost 200,000 miles away from Earth.

How Will We Get There?

A lot has changed since the Apollo program! Getting humans to the Moon will involve new methods and technologies to support larger crews, longer visits, and, eventually, living on the Moon. Here are some of the things NASA and its partner companies are working on now:

The Space Launch System (SLS) Rocket

The Space Launch System (SLS) rocket is designed to be adaptable and is powerful enough to send a human-crewed mission to the Moon and Mars and robotic missions to Saturn and Jupiter. Astronauts need to reach a speed of 24,500 miles per hour to get to the Moon! SLS achieves this speed by attaching two separate rockets to a central rocket called the core stage. Like the Saturn V rocket from the Apollo missions, astronauts and other payloads ride on top of the rocket.

The Orion Spacecraft

Astronauts will travel to the Moon and back in the Orion Spacecraft. It’s only a couple of meters wider than the Command Module of the Apollo missions. However, it has more room on the inside for astronauts because modern computers, sensors, and tools take up less space. When Orion gets back to Earth, the Crew Module uses a heat shield to enter the atmosphere and giant parachutes to land in the ocean.

The Gateway

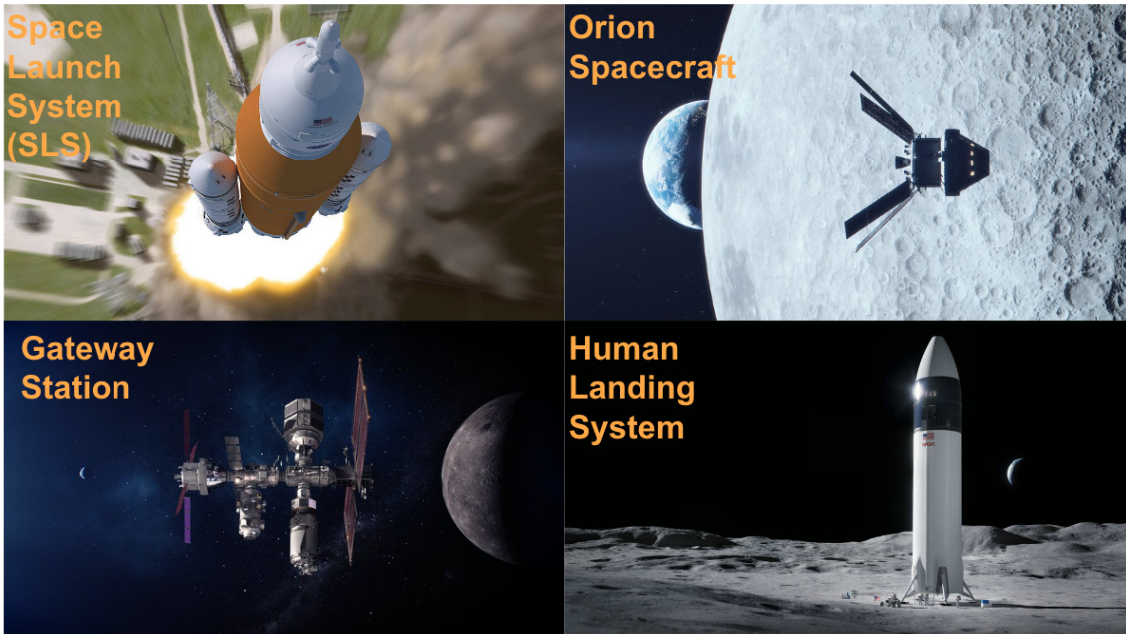
The Gateway will be an outpost in lunar orbit where astronauts transfer from the Crew Module to a lunar lander. It can also store the supplies needed to build and sustain a community on the surface and serve as a future outpost for astronauts launching on missions to Mars and beyond.

Human Landing System

NASA needs another rocket to get humans to the surface of the Moon and back. In April 2021, NASA selected SpaceX to develop a Starship that could land humans on the Moon. The Starship is designed to be more robust than Apollo’s Lunar Module. In the Starship, astronauts can skip docking with the Gateway before landing on the Moon by traveling straight from the Earth.

Artemis Base Camp

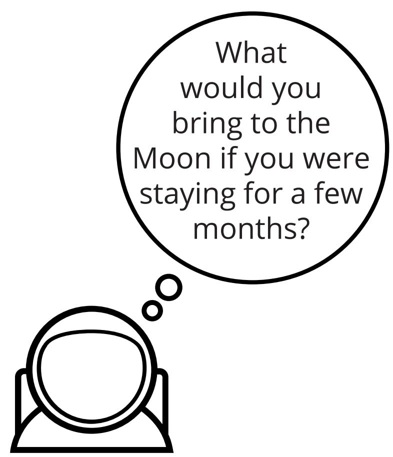
Eventually, NASA wants to send teams of astronauts to live and work on the Moon. However, a lot of science and engineering problems are still being solved. NASA and its partners are designing habitats, space suits, and lunar vehicles. Experiments on the International Space Station and on Earth are helping astronauts understand how to grow food in space. Robotic missions like VIPER will search for water.



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

Learn more about how we are getting to the Moon:
[How we are going to the Moon?]

WHAT IS PLANNED FOR THE FIRST THREE ARTEMIS MISSIONS?

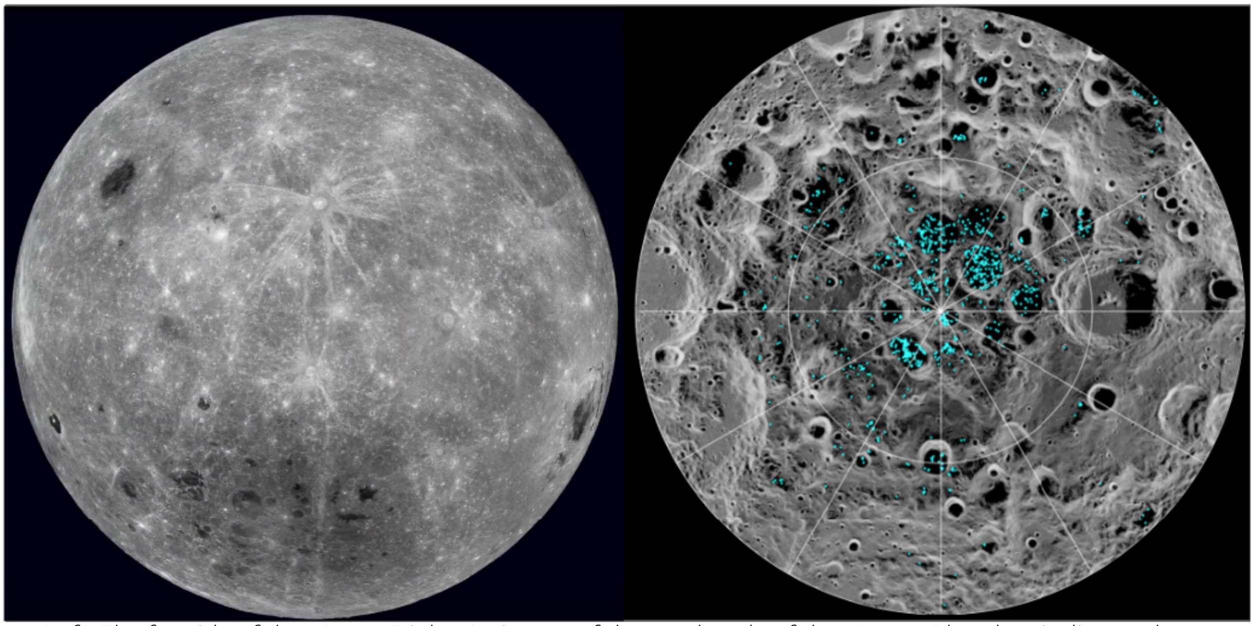


NASA will test the new Artemis in a series of missions"

- Artemis I will be an uncrewed flight that will orbit the Moon. NASA is using this mission to test the SLS rocket and the Orion Capsule without people first.
- Artemis II will be a 10-day crewed flight that will orbit but not land on the Moon. This will test the trajectory for future missions. The Artemis II crew will also test the capabilities of their Crew Module and deep space communication.
- Artemis III will take the humans to the Moon. Artemis III's crew will be selected from a diverse astronaut class. This will be the first time humans have been to the Moon since Apollo 17 in 1972. NASA will use the SpaceX Starship Human Landing System to land on the lunar surface.

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

WHERE WILL HUMANS 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 our closest neighbor. It orbits 238,855 miles (or 394,500 km) from the Earth but is not very comfortable for humans. The Moon's radius (1,080 miles or 1,738 km) is about a quarter of the radius of Earth and its mass is about 1% of the Earth's mass. Gravity on the Moon is only 16% of Earth's. There is almost no atmosphere to protect the surface, so the temperature varies between -400 and 250 degrees Fahrenheit (-250 to 120 degrees Celsius). The Moon's surface is made up of similar material to Earth's surface, but has been ground into a gray powder by billions of years of meteorite impacts.

Learn more about the Moon:
[Overview | Inside & Out – Moon: NASA Science]

Or take a video tour of the Moon:
[NASA | Tour of the Moon]

Scientists thought for a long time that the Moon was a dry place. Any liquid or water ice in the sunlit regions would have evaporated long ago. However, spacecraft have shown that regions inside craters near the poles of the Moon are always in shadow. Without sunlight to melt the ice, it has survived in these cold, dark craters.

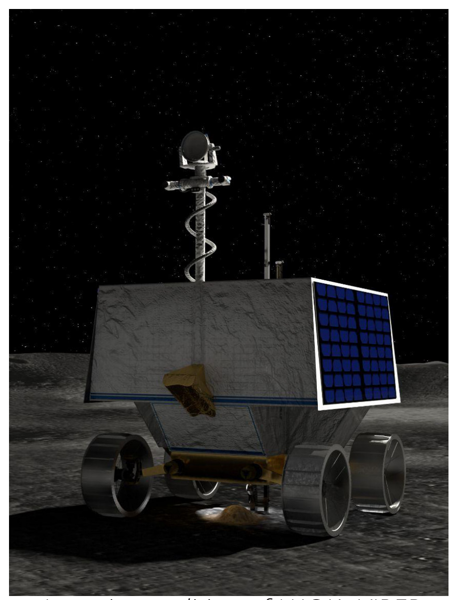
Artemis III will land on the South Pole of the Moon. The Sun will be low in the sky and the shadows will be long. Humans can collect ice to make water to drink and make fuel for rockets. At the South Pole, the rims of craters are almost always in the sunlight. The astronauts can avoid cold temperatures in these regions and use solar panels to collect energy.

Learn more about shadows on the South Pole of the Moon:
[Shadows Near the Moon's South Pole]

Learn more about the history of water on the Moon:
[Inside and Out | Water on the Moon]

WHAT ROBOTIC MISSIONS WILL HELP US PREPARE TO GO TO THE MOON?

Both before and during Artemis missions I, II, and III, several robotic missions will fly to the Moon and help NASA prepare to land humans on the surface.


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

NASA'S VOLATILES INVESTIGATING POLAR EXPLORATION ROVER (VIPER)

VIPER is a golf-sized rover that will study the lunar soil. It will drive inside permanently shadowed regions to help NASA understand how much water is on the south pole of the Moon.

CISLUNAR AUTONOMOUS POSITIONING SYSTEM TECHNOLOGY OPERATIONS AND NAVIGATION EXPERIMENT (CAPSTONE) CUBESAT

The CAPSTONE CubeSat is a microwave-sized satellite that will travel to the Moon and help NASA test its models for navigating the never-been-tried orbit of the Gateway.

POWER AND PROPULSION ELEMENT (PPE) AND HABITATION AND LOGISTICS OUTPOST (HALO)

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

About the ROADS Companion Course

COMPANION COURSE

Our Companion Course program matches our student challenges with teachable lessons and units that you can use to supplement your existing curriculum. The course is aligned with NASA missions and supports Next Generation Science Standards. The program also offers supplies as well as sessions with undergraduate teaching assistants.

You'll find all units and lessons on our website: https://nwessp.org/course/artemis-roads-companion-course/

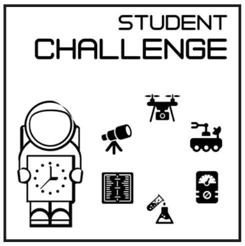
Challenge Mission Objectives & Relevant Companion Course Lessons

UNIT & LESSON	MISSION OBJECTIVE (MO)
Unit 1: Mission Planning **L2:** Documenting a Complex Mission	**MO-01:** Mission Development Log (MDL)
Unit 1: Mission Planning **L3:** Destination, Moon	**MO-02:** Observe and Explain the Moon
Unit 2: Geology **L1:** Investigating the Moon's Surface	**MO-03:** Investigate the Moon's Surface
Unit 3: Life Science **L2:** Life in a "Closed" System	**MO-04:** Life in Closed Systems
Unit 3: Life Science **L3:** Pack Your Moon Kit	**MO-05:** Pack Your Moon Kit
Unit 4: Robotics & Drones **L2:** Path(s) to the Moon	**MO-06:** Path(s) to the Moon
Unit 4: Robotics & Drones **L3:** Rover Development	**MO-07:** Rover Testing and Navigation
Unit 5: Final Mission **L1:** Mission Integration and Final Rehearsal	**MO-08:** Make a Mission Patch
Unit 5: Final Mission **L2:** Final Mission Submission	**MO-09:** Final Mission Closeout

Need a Classroom-Sized Set of Supplies?

NESSP has a limited number of classroom set available for loan.
Learn more at https://nwessp.org/nessp-companion-course-supplies/!

About the ROADS Challenge



The National Student Challenge program gives teams of students in grades 3–12 a chance to model their own NASA mission, including flying to the mission site (via drone), surveying the landscape (via robot), and taking and analyzing samples. Teams document their mission in text and video, then submit their materials to NESSP for the chance to win prizes.

The Artemis ROADS challenge makes for an excellent team activity for an in-class group project, for a school robotics, programming, or other club activity, and for Scout troops or other community organizations.

Register

If you wish to be eligible for prizes or you'd like to request supply support from NESSP, register your team on our website:

https://nwessp.org/artemis-roads-registration-form/

Registration is free and takes just a few minutes.

See https://nwessp.org/artemis-roads-online-resource-guide/ for a description of supplies available to registered teams (as availability allows).

Teams & Mission Advisors

A team is any group of students, grades 3–12, who will be working together to run the challenge. Team members must be enrolled in primary or secondary school or under the age of 18 at the time of registration to participate on the team. The team may be mixed grade. Mission objectives vary for middle and high school teams and are determined using the highest grade level within the team at the time of registration.

This year we ***strongly encourage*** teams to keep their team's membership within our recommended 3–6 students range. If you register a team larger than this, we'll be in touch to discuss whether you can split into two teams.

A Mission Advisor is the adult who will be guiding the team. This person could be a classroom teacher, the advisor for an extra-curricular 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. You may have more than one Mission Advisor.

Program Evaluation

Horizon Research Inc. will contact you after registering for the challenge and request that your team completes 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 to receive support from the NASA Science Activation Program. If Horizon Research Inc. has not contacted your team or you have questions, you can email them at NESSPeval@horizon-research.com.

TEAM RECOGNITION

Teams participating in the NESSP Artemis ROADS Challenge submit results on NESSP website (www.nwessp.org) to acheive the following levels of recongition and rewards:

Teams submit results at: https://nwessp.org/artemis-roads-submissions/

TO MAKE IT TO THE LAUNCHPAD

Registered teams must complete the following by *Feb 15th*:

- Chose a team name and establish a Mission Advisor
- Make a mission patch (MO-08).
- Initiate and make an entry in their MDL (MO-01)
- Complete one of the MO-02 to MO-07

Recognition: Team Name and Mission Patch posted on NESSP Social Media

TO ACHIEVE LOW EARTH ORBIT

Registered teams must complete the following by *March 15th*:

- Launch from the Launchpad
- Complete an additional MO from MO-02 to MO-07 [two total]

Recognition: Team is recognized with a NASA package - contents of this secret envelope revealed later (like a time capsule!)

TO ACHIEVE LUNAR ORBIT

Registered teams must complete the following by *May 10th*:

- Launch from the Launchpad and completed a Low Earth Orbit
- Complete an additional two MOs from MO-02 to MO-07 [four total]
- Participate in at least one SME talk

Recognition: Team is invited to a hub event and a virtual interactive session with an astronaut in late May

TO ACHIEVE LUNAR LANDING

Registered teams must complete the following by *May 10th*:

- Launch from the Launchpad and completed a Low Earth Orbit
- Complete all MO's
- Participate in at least two SME talks

Recognition: Team is invited to a hub event and a virtual interactive session with an astronaut in late May. Eligible for a drawing for a trip to **Kennedy Space Center!**

HOW TO COMPLETE THE MISSION

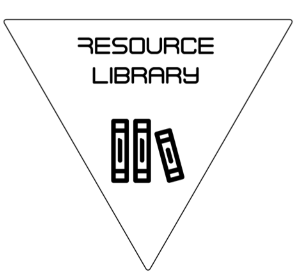
This year NESSP is going back to having an in-person final event, so teams can show us their stuff! Teams may complete the Mission Objective 09 - Final Mission Closeout at a local NESSP hub event or virtually.

The location and dates of hub events will be emailed to teams and posted to NESSP's website and social media. Stay tuned!

ROADS CHALLENGE SCHOOL-YEAR SCHEDULE

Tuesday, August 24, 2022	Registration opens
Wednesday, November 2, 20222	Mission Advisor Q&A
Week of November 7, 2022	"Meet an Expert"
Wednesday, January 11, 2023	Registration ends
Wednesday, February 1, 2023	Mission Advisor Support
Week of February 15, 2022	"Meet an Expert"
Wednesday, March 3, 2023	Mission Advisor Support
Week of March 15, 2023	"Meet an Expert"
Wednesday, March 15, 2023	Initial Submissions Due
Friday, May 5, 2023	Mission Advisor Support
Wednesday, May 10, 2023	Final Submission Due
Week of May 17, 2023	Meet an Astronaut
Late May - July, 2023	Hub Events
August - September, 2023	Kennedy Trip Window

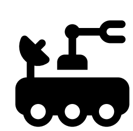
ADDITIONAL SUPPORT



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/

Or you can email us at info@nwessp.org!



ROADS CHALLENGE MISSION OBJECTIVE OVERVIEW

MO-01: MISSION DEVELOPMENT LOG (MDL)

A Mission Development Log is the record of your mission, beginning to end. Document your planning discussions, your trials, failures, and successes, and modifications made as ideas evolve. Each member should contribute!

MO-02: OBSERVE & EXPLAIN THE MOON

For many peoples, the Moon is a calendar in the sky. Discover how for yourself! Keep a lunar observation journal over a multi-week period. What did you learn from your monthlong Moon journaling? What is your Moon story?

MO-03: INVESTIGATE THE MOON'S SURFACE

Despite our challenge's name, there are no roads on the Moon. So what kind of driving surface will your rover encounter? Observe the Moon's surface, investigate lunar regolith, and then design your rover wheels!

MO-04: LIFE IN "CLOSED" SYSTEMS

Earth comes with everything humans need to live — space doesn't. Astronauts need to bring their environment with them in what's called a "closed" system. Investigate the needs of living things, then use your findings to model a system to support a lunar crew.

MO-05: PACK YOUR MOON KIT

Longterm missions - in space - in closed habitat - with a group.... Sounds stressful! How do you keep yourself grounded on Earth while living in space? NASA will provide you with food and air. Now pack what YOU need for wellness on your mission.

MO-06: PATH(S) TO THE MOON

Time to hit the ROAD(S). Following Artemis's real flight trajectory from the Earth to the Moon, simulate the journey with accuracy and safety. Once at the Moon, dock with the Gateway!

MO-07: ROVER TESTING & NAVIGATION

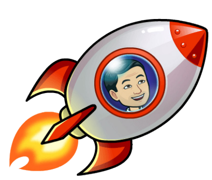
In MO-03, you designed your rover's wheels. Now you'll find out how your rover performs on lunar soil and terrain. Make modifications to improve your rover's capabilities and keep careful logs of your progress in your MDL.

MO-08: MAKE A 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 with imagery?

MO-09: FINAL MISSION CLOSEOUT

IT'S GO TIME! Your team has modeled and tested their mission, now it's time to fly. Teams in-person at a hub will present their MDL to the judges, then complete MOs 06 and 07 live. Virtual teams will submit their MDL and a mission video on the NESSP website.



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 that didn't go as expected. What happened, what did you learn, and what happened next?

MO-01 : Mission Development Log

I. Summary

A Mission Development Log is the record of your mission, beginning to end. Document your planning discussions, your trials, failures, and successes, and modifications made as ideas evolve. Each member should contribute!

II. Mission Advisor Guidance

The Mission Development Log (or MDL for short) documents a team's scientific explorations, initial and final designs, modifications, successes and failures. Yes — successes AND failures! Scientists and engineers rarely get it right the first time. Changes always 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.

While most MDLs will contain sentences and paragraphs, documentation can take many forms! Some ideas include: labeled sketches, diagrams, data tables, calculations, descriptions, bulleted lists, or photos. The types of things your team will document include:

- Initial plans and how they evolved over time
- What worked and what did not work
- A timetable to complete the mission's tasks, with updates throughout the challenge as the timetable shifts — including why the schedule shifted
- Clearly labeled sections that address the criteria or questions in the "deliverables" of each MDL

ALL team members should participate in compiling the MDL — it should not be the work of one single documentarian/secretary.

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 1, Lesson 2 — "Documenting a Complex Mission"

III. Deliverables

At the end of the challenge, teams will submit a PDF of their MDL on NESSP's website. The MDL should:

☐ Include a table of contents that includes each mission objective

☐ Have a title page with team name, team members's names, and the mission patch

☐ Be 40 pages or less (including graphics and tables)

Teams are welcome to track their work in multiple ways that can be converted to a PDF (a Word or Google document, a handwritten notebook, et cetera) and include links to videos or other material.

MO-02 : Observe and Explain the Moon

I. Summary

For many peoples, the Moon is a calendar in the sky. Discover how for yourself! Keep a lunar observation journal over a multi-week period. What did you learn from your monthlong Moon journaling? What is ***your*** Moon story?

Earthrise seen from Apollo 8's lunar orbit. (Credit: NASA)

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 1, Lesson 3 — "Desination, Moon"

II. Mission Advisor Guidance

Teams will make observations of the Moon for at least two weeks and carefully draw the phase of the Moon, the date, and the time they observed the Moon using NASA's Moon Observation Journal. Team members can take turns. For example, each team member can observe the Moon for several days or a week. Direct observations are best, but students can also use online simulators, like Stellarium or SkyCams (see links below) to make indirect observations or infer missing data.

Next, teams will use their lunar observations to make a one-month lunar calendar. The calendar can look like a traditional calendar (or it can look entirely different!), but it should use the lunar cycle to mark the passing of a complete lunar cycle rather than the 30 or 31 days in a month in the commonly used Gregorian Calendar. See Unit 1 Lesson 3 for activities related to discussing patterns or trends they noticed in their Moon observations, and summarize tips for observing and predicting the Moon's appearance.

In many cultures, full moons have names that mark important events that take place during that time of year. The team should do some research and come up with a name for the full moon in their calendar that is relevant to where they live or their culture. The name they choose will be the theme of that month in their calendar. The calendar should be decorated with a drawing or graphic that depicts the full moon name/theme or a story associated with the full moon name. Teams can also research special lunar events that may be occurring and will use their understanding of the causes of lunar phases to include additional information, like what the Earth would look like from the Moon!

MO-02 : Observe and Explain the Moon

What is included in each daily box of the team's lunar calendar depends on the teams' division:

- *Elementary school:* The daily box should include the date and time of the observation, as well as a drawing of the correct phase of the Moon.
- *Middle school:* In addition to the date, time, and correct moon phase, teams should draw the correct position of the Sun, Earth, and Moon (as viewed from above) in each daily box.
- *High school:* Daily boxes should include all of the Grade 3-8 components, but for an extra challenge, students should include the correct Earth phase as viewed from a base on the Moon.

III. Deliverables

In their MDL, teams should:

☐ Include the two-weeks of lunar observations (observation sheet or image of data). They should also note any difficulties observing the Moon or any surprising things they discovered.

☐ Include a copy of their lunar calendar with a description of their full moon name/theme or story. Teams should describe if they filled out their calendar using direct observations, indirect observations (e.g. using a website), or by inferring the correct phase.

☐ Describe the surface of the Moon (maybe draw a picture) and whether the surface change over time? Why or why not?

☐ Address the question below for their division:

- *Elementary school:* Did you observe the Moon at the same time each day? Was there a pattern to your observations? Explain.
- *Middle school:* What will be the phase of the Moon on each team member's next birthday? Use science and math to explain how you figured this out without just looking it up online!
- *High school:* What will be the phase of the Moon on each team member's 30th birthday? Use science and math to explain how you figured this out without just looking it up online!

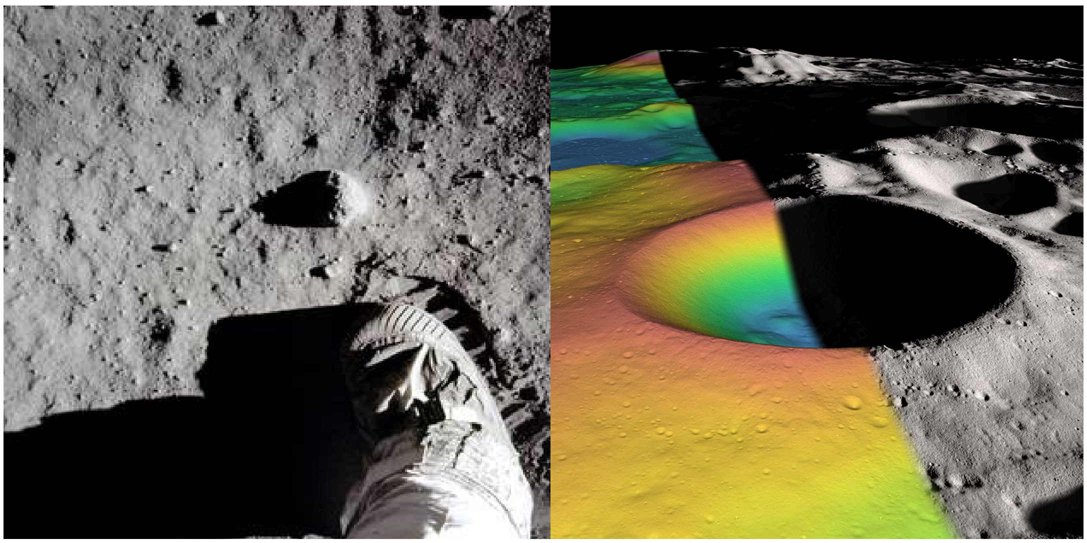
IV. Links

- Stellarium Night Sky Simulation
- Montana Learning Center: All Sky Camera
- NASA: Moon in Motion
- NASA JPL: Moon Phase Activity
- NASA Moon Observation Journal
- More at: https://nwessp.org/artemis-roads-online-resource-guide/

MO-03 : Investigate the Moon's Surface

I. Summary

Despite our challenge's name, there are no roads on the Moon. So what kind of driving surface will your rover encounter? Observe the Moon's surface, investigate lunar regolith, and then design your rover wheels!



(Left) Neil Armstrong from Apollo 11 leaves a footprint in lunar regolith. (Right) An image of Shakleton Crater on the south pole of the Moon with color added to show the steepness of the crater walls. (Credit: NASA)

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 2, Lesson 1 — "Investigating the Moon's Surface"

II. Mission Advisor Guidance

Before NASA sends astronauts back to the Moon, robotic rovers like VIPER will characterize the surface and look for water ice deposits. Scientists and engineers carefully design and test these rovers to make sure they can complete their missions. In this MO, teams will prepare for their mission to the Moon by investigating the environment that rovers will likely encounter, from dust to steep slopes. They will consider what types of wheels might address the challenges of driving on the Moon. In MO-07, teams can use what they learned to prepare their rover for the final challenge course.

This MO progresses through three parts:

- Part A: Observe the lunar surface environment
- Part B: Investigate the observable properties of lunar regolith
- Part C: Design rover wheels that are suited for the lunar environment

Successful completion of this MO includes observing lunar surface characteristics and crater walls.

MO-03 : Investigate the Moon's Surface

II. Mission Advisor Guidance

A. Observing the Lunar Surface Environment

Teams will use the NASA'S Moon Trek and NASA Moon Trek Student Guide to observe the surface of the Moon and explain what features of the Moon's surface their rover will need to account for. Next, teams will use these resources to observe or identify characteristics of sloped crater walls that a rover might encounter on the lunar surface. Teams will observe Shackelton crater and another nearby crater of their choosing. Finally, teams will use their observations to draw a path that a rover like VIPER might travel to investigate the properties of a future outpost on the Moon.

B. Investigating the observable properties of lunar regolith

Teams will use the provided lunar regolith simulant samples to observe properties including:

- Touch and feel (texture)
- Grain size (Foldscopes or other magnifier)
- Grain shape (Foldscopes or other magnifier)
- Reactivity to different objects (water, magnets, light)

Teams should investigate at least three other similar materials (like sand, dirt, and flour) and compare and contrast the properties of regolith to these easier-to-acquire materials.

C. Consider features of rover wheels that may be well suited for the lunar environment

Based on what they learn in Parts A and B, teams should brainstorm and list at least challenges of driving a rover on the south pole of the Moon. Students can research wheel designs (see the Reinventing the Wheel Page in the resouces) and discuss ideas about how particular wheel designs might address the three challenges identified. Finally, the team should draw and describe a new prototype wheel that can address these challenges.

Teams can also design new wheels or temporarily modify the wheels (or tracks) that come with the robot that will be used for the final challenge. In MO-07, teams have the option of using the everyday material that they determined to be the most closely related to the lunar regolith to build a course to test their wheels in. (Note: Please do not permanently modify the wheels of robots loaned from NESSP.)

MO-03 : Investigate the Moon's Surface

III. Deliverables

In their MDL,...

...for Part A, teams should:

- ☐ Include images of Shackleton Crater and other craters they studied using Moon Trek. Teams should compare the properties of the craters and describe features (like steep slopes or boulders) that make them difficult to study with a rover.
- ☐ Include images and/or graphs from Moon Trek or other resources that show the path a rover might travel to study craters near the south pole of the Moon and describe why they chose that path.

...for Part B, teams should:

- ☐ Describe the properties of lunar regolith they observed and how these properties compared with at least 3 other easier-to-acquire materials. Teams should identify the material that is most similar to the lunar regolith. NASA scientists have created artificial "regolith" or "lunar simulants" that have similar properties to lunar regolith. What do you think NASA uses that material for?

...for Part C, teams should:

- ☐ Include a drawing or an image of their prototype rover wheel. Teams should describe how the characteristics of the wheel addresses three challenges of driving on the Moon that they identified.

IV. Links

- NASA Treks | Moon Trek
- NASA Trek Preview on YouTube
- Artemis ROADS Moon Trek Tour for Instructors
- NASA Moon Trek Student Guide
- NASA Glenn Research Center: Reinventing the Wheel
- More at: https://nwessp.org/artemis-roads-online-resource-guide/

MO-04 : Life in "Closed" Systems

Astronauts enjoy plants grown on the international space station. (Credit: NASA)

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- [Unit 3, Lesson 2 — "Life in a 'Closed' System"]

I. Summary

Earth comes with everything humans need to live — space doesn't. Astronauts need to bring their environment with them in what's called a "closed" system. Investigate the needs of living things, then use your findings to model a system to support a lunar crew.

II. Mission Advisor Guidance

In 2015, astronauts ate food grown in space for the first time when they took a bite of red romaine lettuce. Since that first bite, NASA has continued to use the ISS to investigate how to grow edible and inedible plants in space and how plants can improve the environment and health of the astronauts onboard.

In this Mission Objective teams develop a model of life in a closed system like a spacecraft or a habitat on the Moon. A lot of people think of a model car or a model airplane when they hear the word "model," but that isn't what we are talking about here! A scientific model can be a drawing or diagram to explain the parts (components), inputs, outputs, and processes of any complex system. The scientific model might not even LOOK much like the system itself — for example, a flow chart is a type of model. In fact, engineers use flow charts to understand the interactions between parts in a rocket. See Companion Course Unit 3 Lesson 2 for an explanation of models of systems and useful diagrams.

Once teams have developed their model, they will design an investigation that will help them better understand some aspect of the closed system they modeled. For example, how does increasing or decreasing particular input to the system (like light or water) affect an output? There are lots of variables to test, but just like NASA, teams should carefully control their investigation and test one thing at a time so their results are easier to understand. To help guide the team we recommend using the "Planning and Carrying Out Investigations" template from the Unit 3 Lesson 2 of the Companion Course. (If time allows, teams can carry out their investigation. If not, that's OK! Just come up with a question and describe an investigation that you might do to evaluate it.)

MO-04 : Life in Closed Systems

The tools and materials needed for the investigation will depend on the type of question that you would like to explore and answer. NESSP is providing CO_2 detectors and an LED grow light (a technology developed from NASA research) as part of your challenge kit. You can design investigations that use these supplies or other materials that you have available. Some other common materials and tools that could be used in these investigations include:

- Soil, sand, water, or other growing media
- Thermometers, rulers/tape measures, gram scale or balance
- Light measurement app for smartphones
- Dry beans, seeds, or plant starts

III. Deliverables

In their MDL, teams should:

- ☐ Include their model of life in a closed system. The model should be labeled with the parts of their system (e.g. plants, animals, and other non-living objects) and show how parts of the system are connected through the exchange of energy and/or materials (inputs and outputs).
- ☐ Include research question(s) and describe an experiment to investigate them. If the team conducted the investigation, describe how the data helped them understand some aspect of their model? If not, predict what might have been learned.
- ☐ Address the question below for their division:
  - All divisions: Describe how your system will help keep astronauts alive, healthy, and happy.
  - All divisions: What are some of the challenges of maintaining living things in space? What are the benefits?
  - Elementary school: What are the living and nonliving parts of your system?
  - Middle school: How are matter and energy moving and changing within your closed system?
  - High school: How many humans do you think can your habitat support, how did you figure that out, and what is the most limiting factor?

IV. Links

- NASA: Growing Plants in Space
- NASA: Veggie Fact Sheet
- More at: https://nwessp.org/artemis-roads-online-resource-guide/

MO-05 : Pack Your Moon Kit

I. Summary

Longterm missions - in space - in closed habitats - with a group.... Sounds stressful! How do you keep yourself grounded on Earth while living in space? NASA takes care of food and air. Now pack what YOU need for wellness on your mission.

II. Mission Advisor Guidance

NASA makes sure that astronauts have the basic food, water, air, clothing, and shelter that they need to stay alive in space. But after those basic needs are met, what else helps astronauts function at their best for long periods of time in a closed environment?

Astronauts aboard the International Space Station keep track of their mental and physical well-being by journaling at least 3 times per week. For this Mission Objective, each team member will keep a similar daily journal for several days, tracking items they use (other than food, drinks, and personal hygiene products) or activities they do regularly to maintain or improve their emotional and mental health.

Each team member should use their journal and other reflections to select personal items to bring with them to the lunar station. Each student's Moon Kit will have a maximum of 10 items which must fit in a 5" X 8" X 2" (12.7 cm X 20.32 cm X 5.08 cm) bag with a weight limit of 3.3 lbs (1.5 kg) — the same size and weight restrictions for NASA astronauts traveling to the International Space Station! If the team members feel comfortable sharing, have them choose at least one item that is culturally relevant.

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 3, Lesson 3 — "Pack Your Moon Kit"

III. Deliverables

In their MDL, teams should:

- ☐ Include a photo of each team member's Moon Kit, the final dimensions, final mass, and a list of items.
- ☐ Describe how the size and weight limits of this task impacted their choices. What items did students consider bringing, but reject for some reason? What was too big or too heavy to bring? What other limitations did they consider?
- ☐ High school only: Calculate the cost of sending one Moon Kit to space by researching the cost per kg of payload for different rockets. Describe whether the cost impacts the team member's decision to bring any of the items.

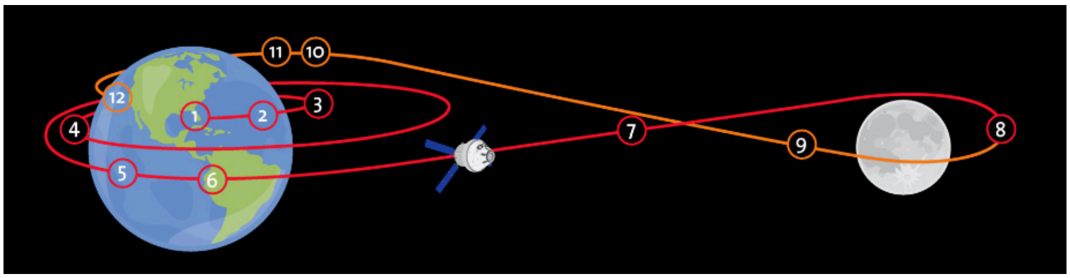
IV. Links

- NASA: The personal preference kit, what astronauts bring to space
- NASA: Jounalint Astronauts Chronicle Missions
- More at: https://nwessp.org/artemis-roads-online-resource-guide/

MO-06 : PATH(S) TO THE MOON

I. SUMMARY

Time to hit the ROAD(S). Following Artemis's real flight trajectory from the Earth to the Moon, simulate the journey with accuracy and safety. Once at the Moon, dock with the Gateway!



The path of of the Orion capsule during the Artemis II mission. (Source: ESA)

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- [Unit 4, Lesson 2 — "Path(s) to the Moon"]

II. MISSION ADVISOR GUIDANCE

For this mission objective, students without a drone will use the Engineering Design Process to develop a balloon rocket capable of sending material from the surface of Earth into low Earth orbit. Students with a drone will be challenged to fly a drone from low Earth orbit to the Moon along the trajectory of Artemis II or Artemis III. Teams are also welcome to try both challenges!

Path A: Balloon Rocket

If the team does not have a drone or chooses not to use a drone, the team can focus on the launch portion of the mission and use the NASA lesson linked in the resources to develop a balloon rocket that can deliver material from Earth surface (the floor) to low Earth orbit (at least 8' high) out of everyday materials. Since rocket launches are expensive, the students should develop a rocket that is reusable and can lift as much mass as possible. The students should measure the "lift" of their rocket by determining how many paper clips it can carry from the floor to the ceiling. Teams should modify their rocket until it can lift as many paper clips as possible using the iterative Engineering Design Process.

Path B: Drone

Teams that have a drone should start by learning the basics of drone flight. Teams should learn how to:

☐ 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

We recommend checking out Companion Course Unit 4 Lesson 2 for some ideas on how to introduce your students to drone flight.

MO-06 : PATH(S) TO THE MOON

Once teams have mastered the basics, they should complete the cruise portion of the mission by learning how to fly their drone from the Earth to the Moon following the trajectory of Artemis II. A practice course can be constructed using the NESSP provided inflatable Earth and Moon. (Note: It is not safe to have students or anyone else hold an object, like the inflatable globes, for the drone to fly near or around. We recommend hanging the globes from the ceiling or supporting them from below.) Teams should attempt to have a flight path as close to the Artemis II trajectory as possible — this may take lots of practice and possible modifications to the drone and/or practice course.

After mastering the trajectory of Artemis II, middle school and high school teams can attempt the more complex trajectory of Artemis III. In this trajectory, the spacecraft orbits the Earth then travels to the Moon where it moves into a polar lunar orbit. After completing several orbits the drone should land near the Moon at the Gateway.

NASA pilots fly many simulations of each mission, so they are prepared when it is time to fly the real mission. Each team should determine how to evaluate whether their pilot is ready for the final mission. Did the pilot achieve that goal?

III. DELIVERABLES

In their MDL, ...

...teams flying on Path A should:

- ☐ Describe the design process for the balloon rocket.
- ☐ Describe (perhaps with a picture) each version of their rocket/lander design, how well it performed in tests, and how it was modified during each iteration.

...teams flying on Path B should:

- ☐ Describe whether each of the basic flying maneuvers were accomplished.
- ☐ Describe whether they were able to fly along the trajectories of Artemis II or III, as well as any challenges they encountered and how they addressed them.
- ☐ Describe the criteria they used to evaluate the readiness of the drone pilot to fly the Artemis trajectory. For example, how many times can that student execute the trajectory without crashing?

IV. LINKS

- NASA JPL Educational Rocket Activity: Heavy Lifting
- Artemis I Trajectory Map
- Artemis II Trajec

MO-07 : Rover Testing & Navigation

I. Summary

In MO-03, you designed your rover's wheels. Now you'll find out how your rover performs on lunar soil and terrain. Make modifications to improve your rover's capabilities and keep careful logs of your progress in your MDL.

A rover in NASA's SLOPE lab. (Credit: NASA)

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 4, Lesson 3 — "Rover Development"

II. Mission Advisor Guidance

Teams will build, program, and test their rovers, preparing them for the final mission. Teams will also build test environments to evaluate and improve the capabilities of their rover. Students should follow the Engineering Design Process and carefully document their rovers capabilities and modifications.

To complete this Mission Objective, teams will need to download software to program their robots onto a computer or tablet. The links for the NESSP-provided LEGO robots are:

- LEGO Spike: SPIKE Prime | Student App Download | LEGO® Education
- LEGO Mindstorm EV3: MINDSTORMS EV3 downloads – LEGO Education

Before they build their rover, teams should get familiar with their LEGO robot (and coding it) by clicking on the "Start" tab and going through the three initial lessons. Note, NESSP provides LEGO robots to challenge teams, but teams are welcome to use other programmable robots, like MakeBlocks or Vex IQs.

Students can then build a basic driving rover. The LEGO software comes with following resources that have instructions for building a basic rover and teach fundamental programming skills related to moving the rover:

- LEGO MindStorm EV3: The "Moves and Turns" lesson in the "Robot Trainer" Unit
- LEGO Spike: The "Training Plan 1" Lesson in the "Competition Ready" Unit

Vexcode VR is another valuable resource if team members want to gain additional experience without a robot. It is a web-based virtual coding environment that allows students to learn block- or text-based code using a virtual robot.

MO-07 : Rover Testing & Navigation

Once teams are familiar with with programming their robot, they should develop blocks of code that they can transmit to their rover to execute the following maneuvers:

- Drive forward in a straight line 1 meter
- Drive forward a straight line a specific distance
- Drive backwards in a straight line a specific distance
- Turn left or right 90 degrees
- Turn left or right 45 degrees
- Code that can be easily modified that tells the robot to drive forward (or backward) a specified distance and turn a specified amount

Images or screenshots of the team's code should be included in the MDL along with a description of what each block does. Teams should also save their programs. This will be helpful for Final Challenge (MO-09).

Next, teams can design test environments where they can evaluate their wheel designs from MO-03 and test their rover's ability to drive on the Moon.

- Teams can build a "lunar dust course" using the easy-to-acquire material that the team identified to have properties similar to the lunar regolith simulant in MO-03.
- Teams should build a "lunar slope course" using wood, foamboard, or cardboard to test the rover's ability to climb up steep slopes.

Both "courses" should be at least 18" long and 12" wide. Students can explore NASA's Simulated Lunar Operations Laboratory for inspiration.

Similar to how engineers use full scale test environments like the Mars Yard to test rovers bound for Mars or the Moon, teams should use their dust and slope test courses to test and adjust the design of their rover. Teams should evaluate how changes to the rover body, wheels/tracks, and driving characteristics affect their rover's ability to drive in the challenging lunar environment. At least three modifications of the rover should be tested using the Engineering Design Process and teams should carefully document how they have modified their rover and the results of their tests.

Note: Materials similar to lunar regolith can be messy. If this won't work in your learning environment, ask teams to skip the "dust course" and just modify the wheel without testing it in regolith-like material (or pick something less messy). During the final challenge, the regolith portion of the course will be separate and optional. Teams will also be allowed to make a "pit stop" and remove the rovers' dusty modified wheels and replace them with the original wheels as they navigate the rest of the challenge course.

MO-07 : Rover Testing & Navigation

Middle school and high teams rovers will be challenged to use the robots color sensor to take scientific data by measuring the color of the surface during the final challenge. Therefore, their robot should be modified to use the color sensor. The following LEGO lessons provide a quick introduction to the color sensor:

- LEGO Mindstorm EV3: The "Colors and Lines" lesson in the "Robot Trainer" Unit
- LEGO Spike: The "Training Plan 3" lesson in the "Competition Ready" Unit

Teams with more experience programming robots or extra time can take on additional challenges of modifying their rover so that it can pick up a ~1"x1" sample and carry it onboard. This will require a little more programming and an extra motor. Students can learn more about this by checking out the following LEGO lessons:

- LEGO Mindstorm EV3: The "Grab and Release" in the "Robot Trainer" Unit
- LEGO Spike: The "Training Plan 2" lesson in the "Competition Ready" Unit

III. Deliverables

In their MDL, teams should:

☐ Include an image or a description of blocks of code developed to complete the basic maneuvers above. Teams should also describe challenges they encountered learning to code and how they addressed them.

☐ Include images of any test courses they have built.

☐ Document the Engineering Design Process including problems identified, ideas generated, prototypes built, and the results of testing their rovers.

☐ Include an image of their final rover design and a description of how various design choices will help that rover drive in the lunar environment.

IV. Links

- NASA's Simulated Lunar Operations Laboratory
- VIPER Hits SLOPE Lab Video
- More at: https://nwessp.org/artemis-roads-online-resource-guide/

MO-08 : 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! How will you represent your Icy Worlds mission with imagery?

Mission patches from crewed NASA missions. (Credit: NASA)

COMPANION COURSE

This Mission Objective aligns with the following Companion Course material:

- Unit 5, Lesson 1 — "Mission Integration and Final Rehearsal"

II. Mission Advisor 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 that represents themselves, their community, and their mission in the Artemis ROADS challenge.

What size should your patch be?

- For a hand-drawn mission patch, we recommend at least half of a regular letter-sized sheet of paper (approximately 8.5" x 5.5").
- For a computer-generated mission patch, your graphic should be ***no smaller*** than 500x500px.

III. Deliverables

In their MDL, teams should:

☐ Include an image of the patch (can be hand-drawn or computer generated)

☐ Explain the components of the patch and their significance to the team

IV. Links

- NASA's E-Clips: Our World - Mission Patches
- Wired Magazine: NASA's Most Awesomely Weird Mission Patches
- More at: https://nwessp.org/artemis-roads-online-resource-guide/

MO-09 : Final Mission Closeout

I. Summary

IT'S GO TIME! Your team has modeled and tested their mission, now it's time to fly. Teams in-person at a hub will present their MDL to the judges and use what they learned to complete their mission live on the hub's challenge course. Virtual teams will 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 5, Lesson 2 — "Final Mission Submission"

II. Mission Advisor Guidance

Before completing the final mission, all teams should submit a copy of their MDL and an image of their mission patch on the final submission page on NESSP's website before the deadline on May 10, 2023. The MDL should:

☐ Have a title page with team name, team members's names, and the mission patch

☐ Include a table of contents that includes each mission objective completed by the team

☐ Be 40 pages or less (including graphics and tables)

Teams that complete MO-08 and at least 4 of the MOs 02 - 07 will be invited to the closest hub event to complete their final mission. All teams can also choose to complete their final mission virtually and submit a video.

The final mission for all divisions will involve the following phases:

- **Launch Phase:** If teams choose not to use a drone, their challenge will be to use their balloon rocket to deliver their payload from the surface of the Earth to low Earth orbit.
- **Cruise Phase:** Teams that have a drone will be challenged to fly the drone from low Earth orbit to the Moon.
- **Landing Phase:** Students at hub events will be presented with a challenge to design a lander!
- **Surface Navigation Phase:** Once landed, students will use their rover to traverse a dust challenge course before descending up and down the steep walls of Shackleton Crater.

An image of the challenge course and scoring criteria will be shared with Mission Advisors on NESSP's website (nwessp.org) prior to the final challenge. Teams should take several hours to prepare using this information. Students will have access to a test course at each hub event but time on the practice course will be limited. Teams should arrive at hub events ready to attempt the challenge with only minor modifications to how they have programmed their robot!

MO-09 : Final Mission Closeout

Description of the Challenge

Launch Phase:

All Divisions: Teams that chose to participate in the Launch Phase should demonstrate the performance of the balloon rocket designed in MO-06. Students should report the number of paper clips their rocket was able to deliver from the surface of the Earth (floor) to low Earth orbit (at a height of 8 feet). The students should demonstrate that their rocket is reusable by launching it twice.

Cruise Phase:

Grades 3-5: The designated drone pilot of the teams participating in the cruise phase will fly from low Earth orbit to the Gateway station following the trajectory of Artemis II (as practiced in MO-06). If the trajectory is not executed correctly (or the drone crashes). The pilot can reset at low Earth orbit and try again. Each team will have five attempts to execute the trajectory over a total of 8 minutes.

Grades 6-8: Teams participating in the cruise phase will fly from low Earth orbit to the Gateway station following the trajectory of Artemis III (as practiced in MO-06). The drone must make at least 3 lunar orbits before landing at the Gateway. If the drone crashes during the portion of the trajectory between the Earth and the Moon, the drone should be reset at low Earth orbit, so it can make another attempt. If the drone crashes during lunar orbit, the drone should be reset at the Gateway and then restart its lunar orbit. Each team can reset their drone 5 times over a total of 8 minutes.

Grades 9-12: Same as Grades 6-8 except, except the drone can be reset a total of three times over a total of 8 minutes.

Landing Phase

Surprise! Sometimes in space travel, teams must work together to address new unexpected challenges. Teams participating at hub events will complete the landing phase challenge on site!

MO-09 : Final Mission Closeout

Surface Navigation Phase

Grades 3-5: Teams will test the wheels and rover designs from MO-07 by driving in a straight line across the Lunar Dust Course. Teams will retrieve their rovers and can switch back to their original wheels (or not) before the start of the Lunar Crater Course. In this course, rovers must descend into Shackleton Crater, measure the color of surface material at the bottom of the crater. Next rovers must exit the crater by choosing one of 4 steep ramps.

Grades 6-12: Same as Grades 3-5 except students may choose to challenge themselves on a Lunar Dust Course that is longer and includes obstacles that the rover must steer around by sending blocks of code to their rover. In the crater, the rover will take two measurements, one from the permanently shawdowed region of the crater and another from the non-permanently shaded region and collect sample(s) for bonus points. The rover will then exit the crater by choosing the appropriate steep incline.

What should teams at the in-person challenges present from their MDL?

Teams doing the challenge in-person will be asked to:

- ☐ Show their Lunar Calendar from MO-02 and describe how they designed it. Teams should also explain their answers to the questions they addressed in their MDL.
- ☐ Show or describe their Life in a Closed System Model from MO-04 and what they learned from it. Include an explanation of the three questions the team's division, using the model as the visual component.
- ☐ Show or describe at least one example Moon Kit from the "Pack Your Bags" activity in MO-05. Teams should describe the size and weight of their package and how these constraints and other considerations impacted their choices.
- ☐ Describe what they learned about the lunar surface in MO-03 including answers to questions addressed in their MDL.
- ☐ Describe how they used information learned in MO-03 to test and improve their rover design in MO-07. Students can include or refer to visuals in the MDL of their test environments and prototypes of their wheels and rovers.
- ☐ Show their mission patch from MO-08 and describe why they designed in the way they did.

If your team didn't complete all the MOs listed above, that is nominal (NASA speak for A-OK)! Just present the MOs your team did complete.

MO-09 : Final Mission Closeout

Completing the Challenge Virtually? Submit a Final Challenge Video!

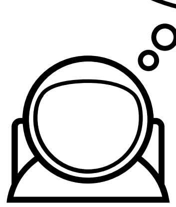
Virtual team's ' MOs will be presented in the MDL they submit online, so teams will only need to submit a video that includes evidence that the team completed the final mission on a home-made course.

In the team video:

- ☐ Teams with drones should show the drone flying along the trajectory of Artemis II or III depending on the division. Teams are allowed to reset their drone following the criteria for live teams. Videos should show each attempt.
- ☐ Teams that built balloon rockets should demonstrate the performance of their rocket by showing the number of paper clips their rocket was able to deliver from the surface of the Earth (floor) to low Earth orbit (at a height of 8 feet). The teams should also demonstrate that their rocket is reusable by launching it twice.
- ☐ Teams should show the rover with the wheels or tracks the team designed driving through a test bed of material similar to lunar simulant that is at least 18" long. (optional)
- ☐ Teams should show the rover making color sensing measurements and retrieving samples on the crater challenge course. Instructions for building a home-made course will be provided when we reveal the final challenge course to all teams.

Teams submit the MDL and videos at:

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



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 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:

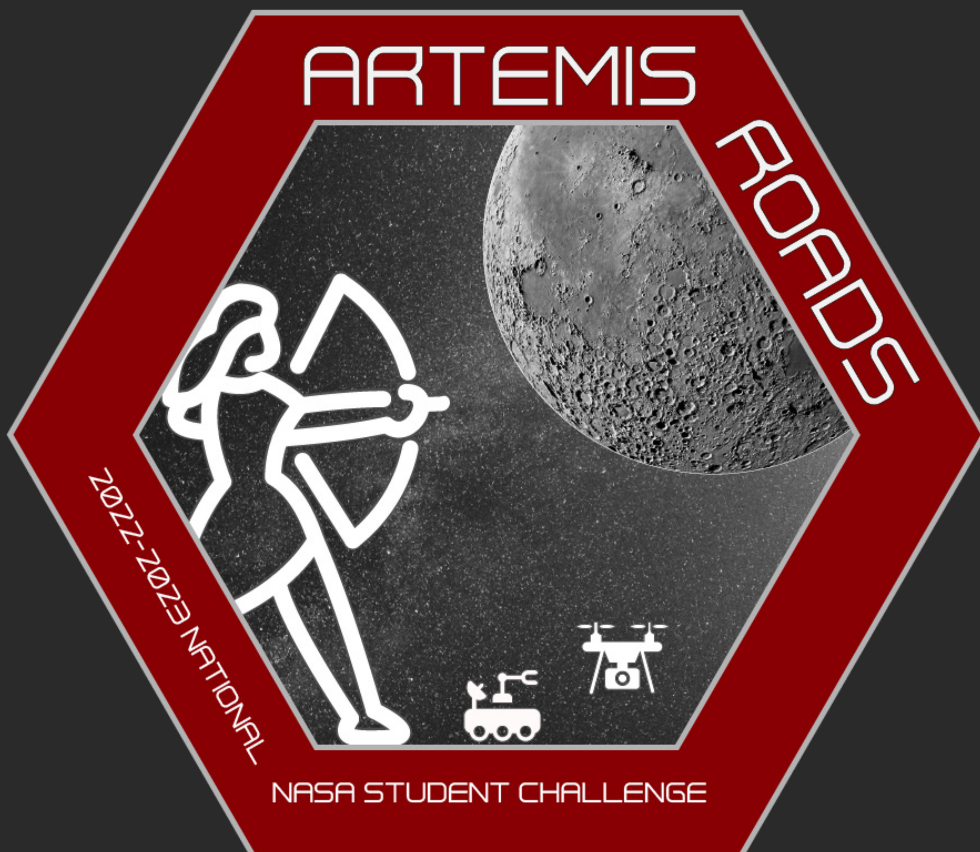
- What happened?
- What did you learn from it?
- What did your team do next?

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/



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