National Aeronautics and
Space Administration

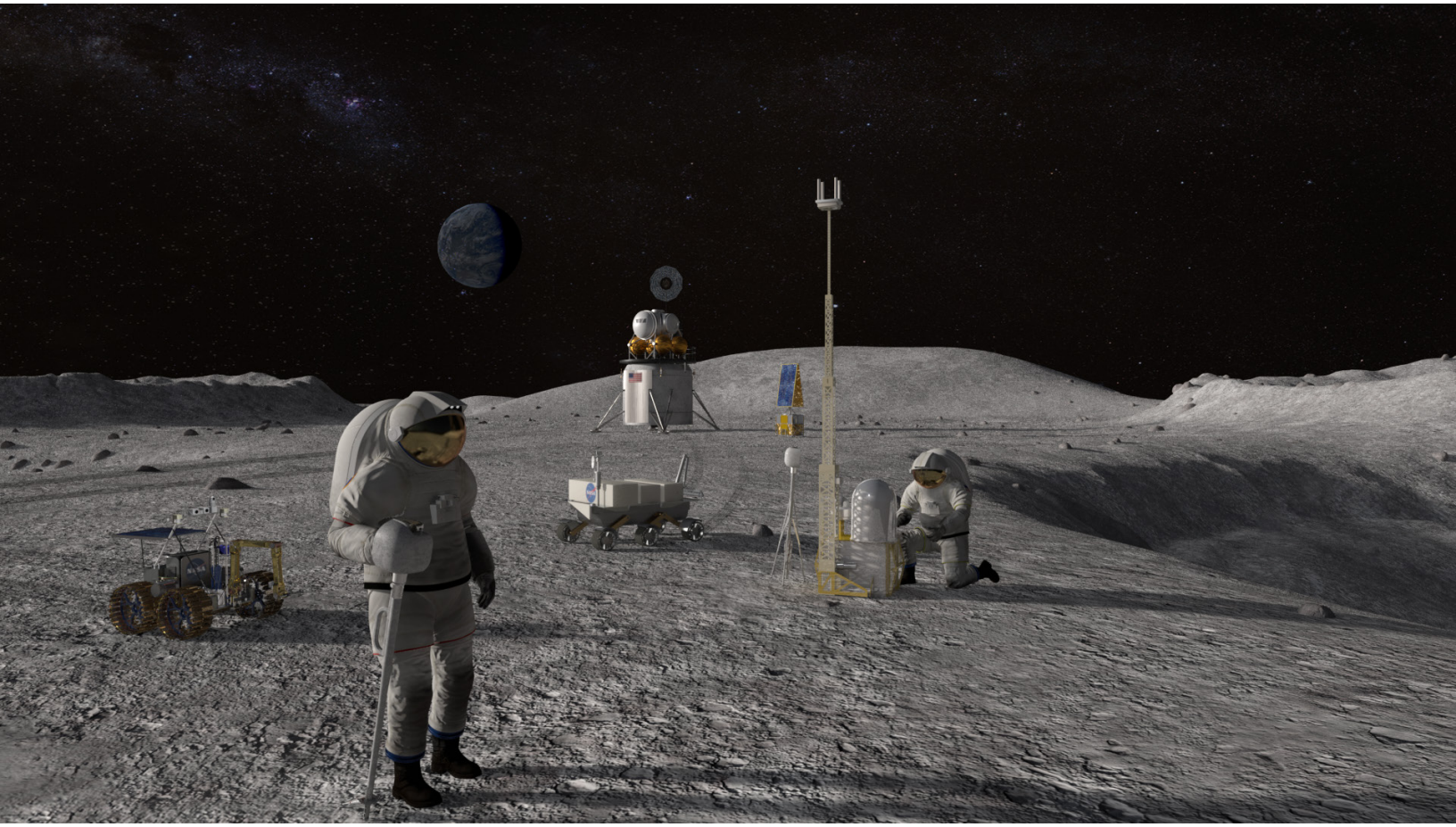
NASA STEM ACTIVITY

HABITAT PLANNING

OVERVIEW

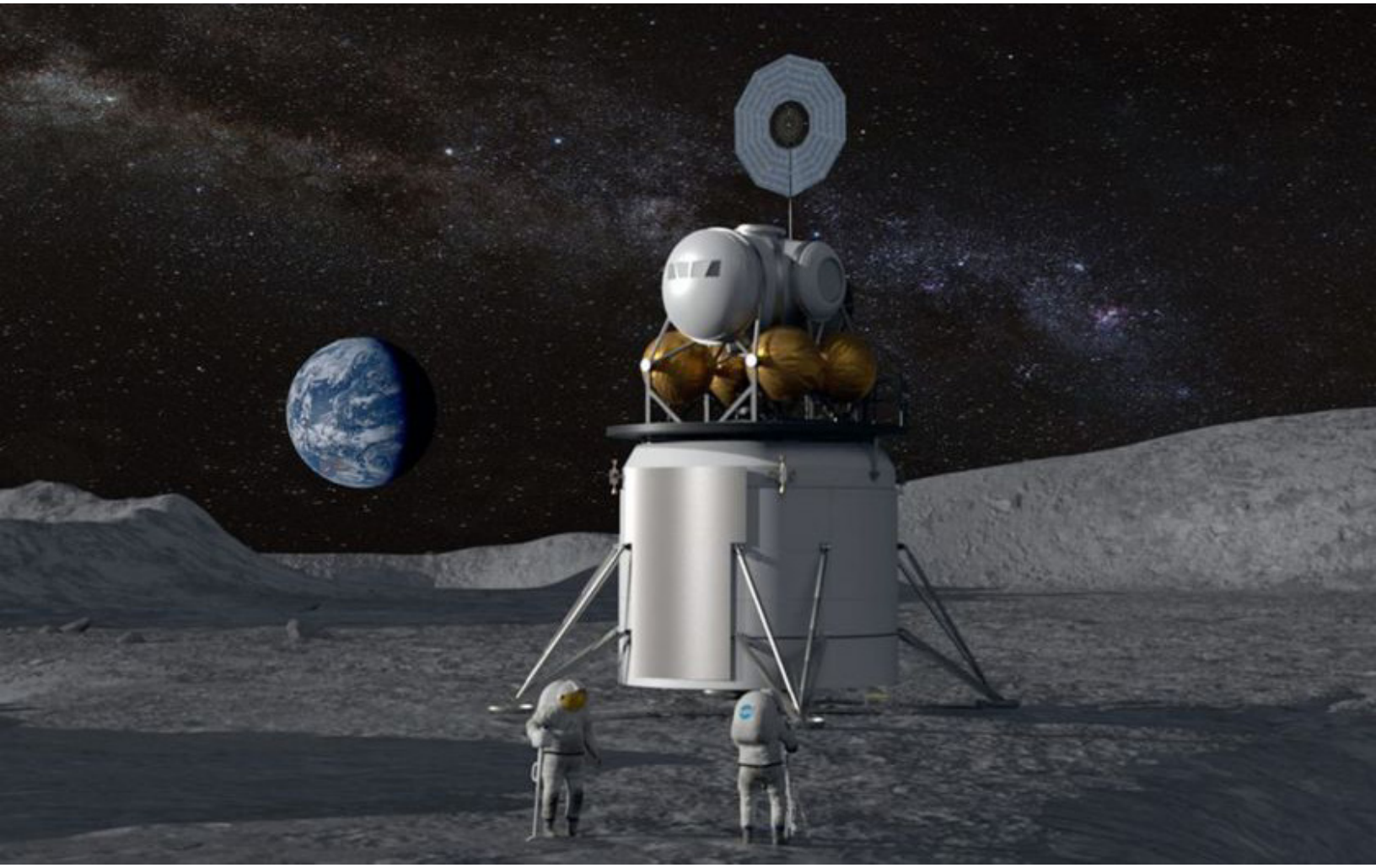
NASA has been given its most ambitious and challenging mission in half a century: to rapidly accelerate its human lunar program and land the first woman and the next man on the surface of the Moon in 2024. This program is named Artemis, after the Greek goddess of the Moon. Artemis is the twin of Apollo, the historic NASA program that first landed humankind on the Moon 50 years ago. Artemis will establish a long-term presence in lunar orbit and on the surface of the Moon. The goal of Artemis is continuous exploration of the lunar surface through a sustainable human presence on the Moon.

This is not an easy task. Even though some of the hardware, such as the Space Launch System (SLS) and Orion, have been in development and are nearing completion, there are several critical technologies, including spacesuits, Gateway modules and a lunar lander, that must be engineered, designed and built at a rapid pace. While NASA and its commercial partners are at work developing this hardware, you can participate as well. These activities simulate some of the same challenges faced by NASA astronauts, engineers, and scientists. It is your mission to solve these challenges throughout the lunar mission, from demonstrating the distance of the Moon from Earth, to launching a rocket and keeping astronauts healthy after landing on the Moon, We are counting on you!



LANDING ON THE MOON

Artemis' goal is to land American astronauts on the Moon's South Pole. Later missions will add more aspects to the landing site as steppingstones towards sustainable deep space exploration. The Moon's South Pole is the landing site because of the water ice discovered in the region. Using water as a resource can help create clean air to breathe, clean water for humans and plants, and even hydrogen for rocket fuel. These sustainable resources will lead to permanently crewed bases on the lunar surface, where more exploration and research can take place. Sustainability will allow astronauts to stay for longer periods of time, possibly for a future, permanent presence on a lunar base.



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HOUSTON | WE HAVE A PODCAST

Houston We Have a Podcast: Space Habitats

We Are Going

HABITAT PLANNING

Objective

During this activity, you will:

- Discuss the basic needs for a permanent habitat on the Moon's surface.
- Discuss possible daily activities that lunar astronauts would do.
- Create a plan for a lunar habitat.

Materials

- Moonquakes article (following pages)
- Paper
- Large drawing paper
- Colored pencils

Procedure

1. Read the article "Moonquakes: NASA Astronauts May Need Quake-Proof Housing"
2. Discuss what kinds of work astronauts might be doing on the Moon, and make a list of the most likely activities.
3. Discuss what you do to relax, and make a list of activities that you think astronauts on the moon might do.
4. Discuss and list things that would be needed to keep astronauts healthy, and alive, on a day-to-day basis.
5. List needed resources for waste management and recycling.
6. Think about, or walk around your house, considering all of the rooms and thinking about what is done in them.
7. Go through your lists and identify the type of room that each activity would use. Add any extra rooms that would be needed and are not part of a normal house.
8. On a large sheet of paper, draw a rectangle that is 20 in. x 24 in. This represents the area of your lunar habitat. Use a ruler to help you draw rooms and buildings. Consider:
9. How much space is needed for each of your requirements?
10. Can any of the spaces serve two purposes?
11. Include a space (8 in. x 8 in.) to house plants or animals that may be needed to provide food.

Conclusion

- Were there any spaces that share activities? Why did you combine those activities? *Answers will vary, but might include options such as cooking and health because they both need water, or recreation and sleep, as the room could change purpose at night.*
- Were there any rooms that needed water supplied to them? If yes, did you put those rooms close together to minimize pipes needed? *Water is needed for kitchen, bathrooms and health area at a minimum.*
- Would an astronaut who is not feeling well be able to rest while the others were working? *Answer will depend on their design.*

Reference

Modified from Field Trip to the Moon LRO/LCROSS ed. Informal Educator's Guide: https://go.nasa.gov/2l2Kzv5

NASA astronauts may need quake-proof housing.

NASA astronauts are going back to the Moon, and when they get there they may need quake-proof housing.

That's the surprising conclusion of Clive R. Neal, associate professor of civil engineering and geo-logical sciences at the University of Notre Dame, after he and a team of 15 other planetary scien-tists reexamined Apollo data from the 1970s. "The Moon is seismically active," he told a gathering of scientists at NASA's Lunar Exploration Analysis Group (LEAG) meeting in League City, Texas, last October.

Between 1969 and 1972, Apollo astronauts placed seismometers at their landing sites around the Moon. The Apollo 12, 14, 15, and 16 instruments faithfully radioed data back to Earth until they were switched off in 1977.

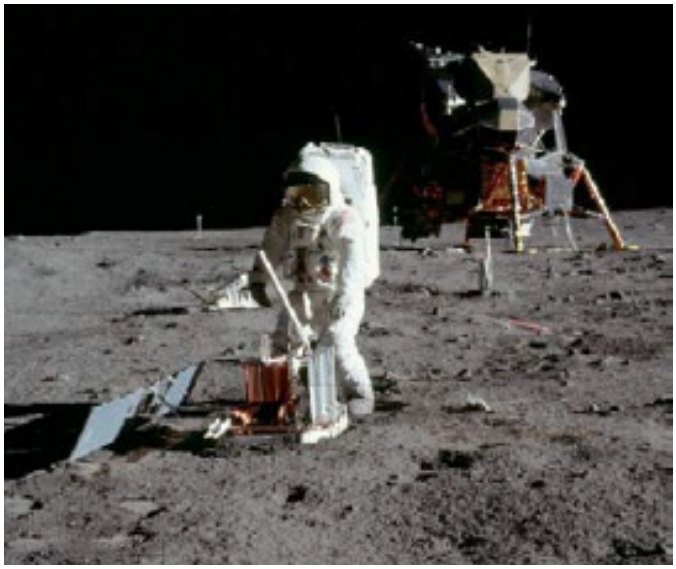
And what did they reveal?

There are at least four different kinds of moon-quakes: (1) deep moonquakes about 700 km be-low the surface, probably caused by tides; (2) vi-brations from the impact of meteorites; (3) thermal quakes caused by the expansion of the frigid crust when first illuminated by the morning sun after two weeks of deep-freeze lunar night; and (4) shallow moonquakes only 20 or 30 kilometers below the surface.

The first three were generally mild and harmless. Shallow moonquakes, on the other hand, were doozies. Between 1972 and 1977, the Apollo seis-mic network saw 28 of them; a few "registered up to 5.5 on the Richter scale," says Neal. A magni-tude 5 quake on Earth is energetic enough to move heavy furniture and crack plaster.

Furthermore, shallow moonquakes lasted a remark-ably long time. Once they got going, all continued more than 10 minutes. "The Moon was ringing like a bell," Neal says.

On Earth, vibrations from quakes usually die away in only half a minute. The reason has to do with chemical weathering, Neal explains: "Water weak-ens stone, expanding the structure of different min-erals. When energy propagates across such a com-pressible structure, it acts like a foam sponge—it deadens the vibrations." Even the biggest earth-quakes stop shaking in less than two minutes.



Buzz Aldrin deploys a seismometer in the Sea of Tranquillity.

The Moon, however, is dry, cool and mostly rigid, like a chunk of stone or iron. So moonquakes set "Any habitat would have to be built of materials that are somewhat flexible," so no air-leaking cracks would develop. "We'd also need to know the fa-tigue threshold of building materials," that is, how much repeated bending and shaking they could withstand. it vibrating like a tuning fork. Even if a moonquake isn't intense, "it just keeps going and going," Neal says. And for a lunar habitat, that persistence could be more significant than a moonquake's magnitude.

What causes the shallow moonquakes? And where do they occur? "We're not sure," he says. "The Apollo seismometers were all in one relatively small region on the front side of the Moon, so we can't pinpoint [the exact locations of these quakes]." He and his

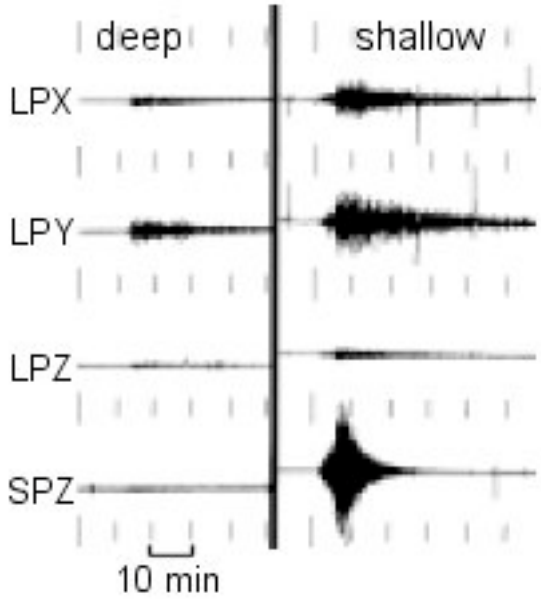
colleagues do have some good ideas, among them being the rims of large and relatively young craters that may occasionally slump.

"We're especially ignorant of the lunar poles," Neal continues. That's important, because one candi-date location for a lunar base is on a permanently sunlit region on the rim of Shackleton Crater at the Moon's South Pole.

Neal and his colleagues are developing a propos-al to deploy a network of 10 to 12 seismometers around the entire Moon, to gather data for at least three to five years. This kind of work is necessary, Neal believes, to find the safest spots for perma-nent lunar bases.

And that's just the beginning, he says. Other plan-ets may be shaking, too: "The Moon is a technolo-gy test bed for establishing such networks on Mars and beyond."

MOONQUAKES



Representative lunar seismograms from the Apollo 16 station.

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