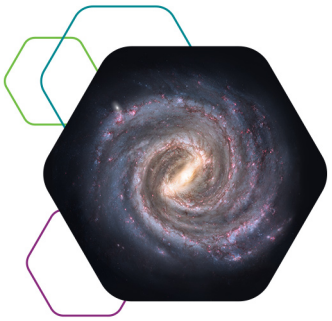

# FACILITATOR GUIDE

# Pack a Space Telescope

## Learning objectives

- Engineers design, build, and test new technologies to study the universe.
- Careful planning and design help us make new discoveries and better understand Earth and space.
- NASA teams work together to launch, guide into orbit, and operate a space telescope.

## Materials

- Ariane 5 Rocket "testing site" (PVC pipe stand)
- Honeycomb-shaped golden mirror cards (100)
- Sunshield cards (100)
- String
- Clear tape
- Scissors
- James Webb Space Telescope poster
- Activity and facilitator guides
- Information sheets
- *Tips for Leading Hands-on Activities*
- Colored construction paper and markers (optional)

**The Explore Science toolkit comes complete with all necessary materials for this activity.** Materials are also readily available to create or restock activity kits. Graphic files can be downloaded from www.nisenet.org. The hexagonal shaped cards in the activity were custom printed by Makeplayingcards.com. You can upload the digital artwork provided to order more.

## Safety

Use caution if using scissors with young children.

## Advance preparation

- You may choose to pre-cut 12" lengths of string for participants before they start doing the activity, especially if it's a busy day, or you can allow participants to cut the string on their own.

## Notes to the presenter

**Give each participant:** One golden mirror array card, one sunshield card, two 12” lengths of string, and some tape.

The challenge is to construct a model of the James Webb Space Telescope (mirror and sunshield), fold it to pack into the rocket payload compartment (PVC tube), and deploy or open it up by pulling only on the two pieces of string that are taped to the model.

Challenge participants to design, build, and fold their own telescope models. If they get stuck, use the information sheets and poster images as inspiration. But remember that there is no single way to design the telescope. The Webb telescope went through iterations, and there were many preliminary designs. To make the activity more challenging, suggest that participants make their own mirror array using construction paper or add additional materials and components.

The hexagonal James Webb Space Telescope mirror cards in this activity depict a representation of the gold plated mirror segments on one side, and reference some of the images and objects the Webb may study on the other side. Planned research includes, the early history of our universe, the development of our solar system, how other stars and planets form, and the potential habitability of planets orbiting nearby stars.

If participants have trouble getting the string to stay taped, suggest they tie a knot at one end and then tape that to the paper to help it stay in place.

This activity may prove challenging for very young children because they are still developing the fine motor skills needed for cutting, taping, and positioning the string; they may therefore require more time and help. Encourage young children to work with an adult or older sibling, and suggest that these partners then allow the young child to do the honors of pulling strings to deploy the telescope.

**Conversational prompts**

After a brief conversation about the challenges of deploying a satellite and the design of the Webb telescope, encourage participants to select a mirror, a sunshield, two pieces of string, and some tape. Explain that NASA engineers were inspired by the Japanese paper art, origami, when designing a telescope the size of a tennis court that will fold into a compartment on an Ariane 5 rocket.

Get creative! There is more than one way to fold the mirror configuration. The final telescope designs do not have to look like the Webb telescope. In fact, there were several initial designs for what was originally called the “Next Generation Space Telescope.”

- Show visitors some of the early designs as inspiration. Participants will notice the early designs are very different from the final design.
- Ask them why the engineers might have made changes to their own designs.
- Encourage visitors to think about any changes they might make to their own design after they test deployment.

## Difficult concepts

Participants may have heard the word “satellite” in other contexts. A satellite is an artificial object placed into orbit around a planet or other object in space. The James Webb Space Telescope is a type of satellite that will orbit around the Sun once it is deployed. It will look out to study the universe.

While the distance between Earth and the telescope will be over a million miles, this is a relatively

small distance out into the overall universe. Hearing the name “Space Telescope,” many people may believe that the satellite hosting the James Webb Space Telescope travels through space to get closer to distant galaxies and capture amazing images. In fact, scientists chose the location for the telescope not to get closer to the objects it images, but to avoid the distortion created by light being bent by Earth’s atmosphere and to better access infrared wavelengths of light energy.

The James Webb Space Telescope must also orbit far enough away from the Sun and be tilted the right way so that the sunshield can protect the sensitive instruments from the Sun’s light and keep them cool enough to measure the infrared light coming from objects in space. The ability to image far-away galaxies with such incredible detail comes from the telescope’s large mirror and infrared detectors. The bigger a telescope mirror is, the more light can be collected and focused into the instrument. The more light collected, the better fainter and more distant objects can be imaged. This is why engineers designed the telescope mirror to be carefully stowed in the rocket and then unfolded to maximize its size.

## Staff training resources

Refer to the *Tips for Leading Hands-on Activities* sheet in your activity materials.

- An activity training video is available at vimeo.com/245834892
- A content training video is available at vimeo.com/245835367
- The NISE Network has a curated list of programs, media, and professional development resources in the NASA Wavelength Digital Library that directly relate to the toolkit. These resources can be viewed and downloaded from nasawavelength.org/users/nisenet.

## Credits and rights

This activity was adapted from Deploy a Satellite, developed by educators at the Space Telescope Science Institute and used with permission.

### Mirror card image description and credits


1. Simulated reionization as the Universe cooled after the Big Bang and galaxies began to form. *Credit: M. Alvarez, R. Kaehler, and T. Abel, University of Toronto*
2. An artist's impression of CR7, a bright, distant galaxy. *Credit: European Southern Observatory, VLT /M. Kornmesser*
3. Sombrero Galaxy. *Credit: NASA/Hubble Heritage Team*
4. Disco Lights galaxy cluster. *Credit: NASA, ESA, CXC, NRAO/AUI/NSF, STScI, and R. van Weeren , Harvard-Smithsonian Center for Astrophysics*
5. Barred spiral galaxy NGC 613. *Credit: ESO/IDA/Danish 1.5 m/ R. Gendler, J-E. Ovaldsen, C. Thöne, and C. Feron.*
6. Infrared image of the "Mountains of Creation". *Credit: NASA/ JPL-Caltech/ L. Allen, H Harvard-Smithsonian Center for Astrophysics*
7. "Pillars of Creation" in visible light. *Credit: NASA/ESA/M.Livio/ Hubble 20th Anniversary Team, StScI.*
8. Witch Head Nebula. *Credit: NASA/JPL-Caltech*
9. Artist's concept of an exoplanet and its moon. Credit: A. Field, *StScI.*
10. Infrared image of stars forming in M17 SWex. *Credit: NASA/ JPL-Caltech/ Penn State/ DSS*
11. Artist's impression of a distant star. Credit: ESA/ C. Carreau
12. Simulated reionization as the Universe cooled after the Big Bang and galaxies began to form. *Credit: M. Alvarez, R. Kaehler, and T. Abel, University of Toronto*
13. Mosaic image of starburst galaxy, Messier 82. *Credit: NASA, ESA, and The Hubble Heritage Team (STScI/AURA*
14. *Artist's impression of the planet HAT-P-7b, a gas-giant.* Credit: University of Warwick/Mark Garlick
15. Surface of Jupiter's moon, Europa. *Credit: NASA/ JPL-Caltech/DLR*
16. Simulation of Intergalactic Medium. *Credit: Kavli Institute for Cosmology, Cambridge*
17. "Pillars of Creation" in infrared light. *Credit: NASA/ESA/M.Livio/ Hubble 20th Anniversary Team, StScI.*
18. Artist's impression of a newly formed star and protoplanetary disk of dust and gas. *Credit: University of Copenhagen/Lars Buchhave*

Overall design inspired NASA social media graphic created by A. Field (STScI).

Images of Webb components, construction, and artist's concept courtesy NASA/ ESA/ CSA/ The Space Telescope Science Institute.

Ariane 5 rocket illustration courtesy Arianespace.

Images of spiral galaxy courtesy NASA.

Next Generation Space Telescope initial designs courtesy NASA/ The Space Telescope Science Institute.

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