WORLD BUILDING ON MARS

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Abrams Planetarium

MICHIGAN STATE UNIVERSITY MUSEUM
WHERE SCIENCE AND CULTURE MEET

School of Journalism
MICHIGAN STATE UNIVERSITY

NASA

DESCRIPTION OF THE PROJECT

The *World Building on Mars* curriculum was developed as part of a TEAM II RORR project (award # 80NSSC21M0039) awarded by the National Aeronautics and Space Administration (NASA). The project was a collaboration between three departments at Michigan State University — Abrams Planetarium, the MSU Museum, and the School of Journalism.

This curriculum gives students agency in developing their own city on the planet Mars. Along the way, they will learn about the planet and the challenges humans face in exploring the red planet with actual people instead of rovers, drones, and other mechanical means. Students will also explore concepts from urban planning so they can build effective, equitable, and inclusive environments on Mars. This will allow them to draw from their own experiences and aspirational ideas related to cities and towns on Earth. With their newfound knowledge, students will get to choose where they want to build their cities on Mars, which buildings they think are most important, and how to lay them out. There are no wrong answers — only the need to justify *why* they want what they want!

The curriculum was piloted with several classes and student groups ranging from 5th to 12th grade in several local school districts using both virtual and in-person learning. It was designed to be flexible enough to work across many different learning situations, grade levels, and classroom needs. Educators are encouraged to use all or just the parts of the curriculum that best meet their instructional goals and differentiating needs.

The pilot version of the curriculum included an opportunity for students to see their cities come to life with an artist who turned their drawings into 3D models and placed them in the students' chosen Martian landscape. While this is not something the project team can offer, we do have the original cities students designed available for students to look at and get inspired.

ACCESSIBILITY NOTES

We have made this PDF accessible with alt-text or image descriptions for all images as well as to work with screen readers. Throughout we offer suggestions on how to make suggestions for accessible ways for students to participate. We offer several worksheets for educators' convenience. These are not required as long as students have some way of recording the ideas represented in the worksheets.

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NOTE TO TEACHERS ABOUT GOOGLE JAMBOARDS

Jamboard is a digital interactive whiteboard developed by Google. Links to any Goolge Jamboard in this document will create a copy from the master document in your personal google account. To revisit the Jamboard you are teaching from, please go to your Google account.

MARS LESSON 1A:

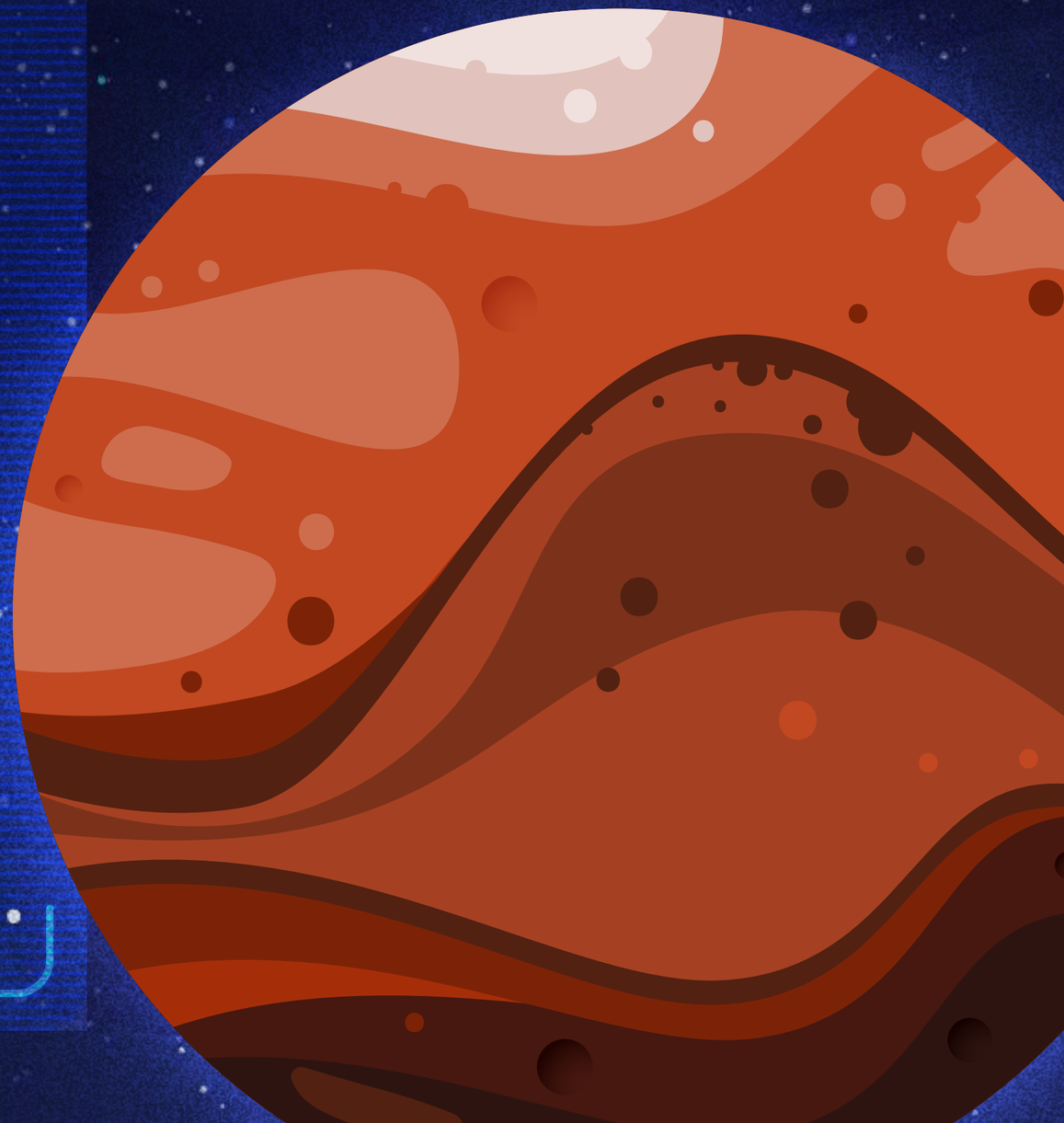
INTRODUCTION

TIME REQUIRED: **15 MINUTES**

OBJECTIVES

Students will be able to:

- Identify some ways that Mars is similar to Earth
- Name some resources available on Mars
- Give their own reasons for why we should go to Mars



MATERIALS NEEDED

- **Images of Mars from various NASA Mars Landers**

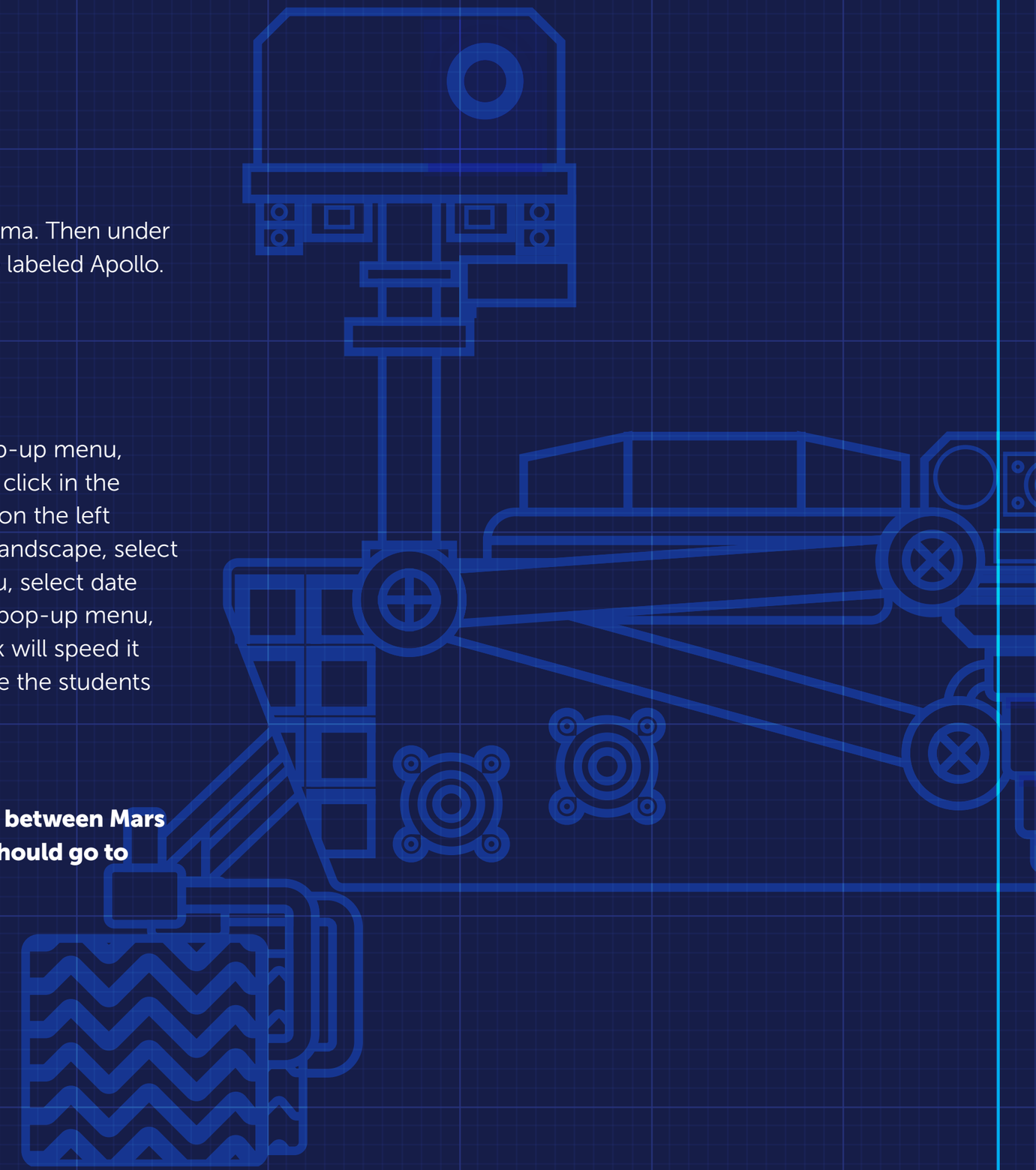
  Alternative: worldwidetelescope.org/webclient
  Go to the bottom left-hand corner, find “Look At,” and select panorama. Then under “imagery” just to the right, select any of the panoramas except those labeled Apollo. Then rotate the image by clicking and dragging.

- **Images of Mars taken throughout a 24-hour period**

  Alternative: stellarium.org
  Download the free software. Then open it up. On the left hand pop-up menu, select the top option for location. Change planet to Mars and then click in the middle of the map on Mars. Exit out of the location window. Then on the left pop-up menu, select the sky and viewing options window. Under landscape, select Mars. Then exit out of that window. On the left-hand pop-up menu, select date and time to make sure that window is visible. Then on the bottom pop-up menu, click on the double arrows facing right to speed time up. Each click will speed it up more. Select the play button to stop it again if you need to. Have the students watch the sky over several days.

- **A way of recording student ideas on similarities and differences between Mars and Earth, resources on Mars, and ideas for why they think we should go to Mars**

  Possible ideas:
  - Virtual Option: **Jamboard**
  - In-person Option: **Worksheet**
  - In-person Option: Sticky notes on a board



ACTIVITY 1:

IMAGES FROM MARS LANDERS

TIME REQUIRED: **3 MINUTES**

Have students note observations they make about Mars at each site. This could be by noting it somewhere or sharing out as a group.

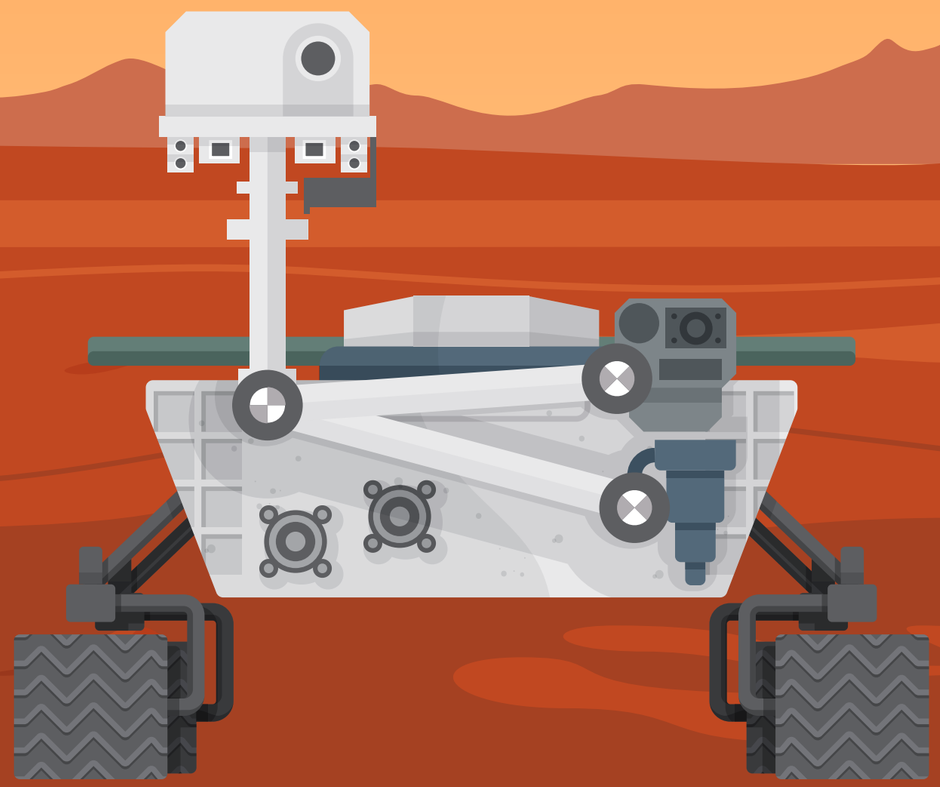
Alternative: For students on their own computers, allow them to choose and explore on their own. This part could be done asynchronously.

If you find that the Perseverance panorama is not yet freely available in WorldWide Telescope, use this direct link: https://worldwidetelescope.org/webclient/?wtml=http://data1.wwtassets.org/packages/2021/02_perseverance_first_360_panorama/perseverance_first_panorama.wtml

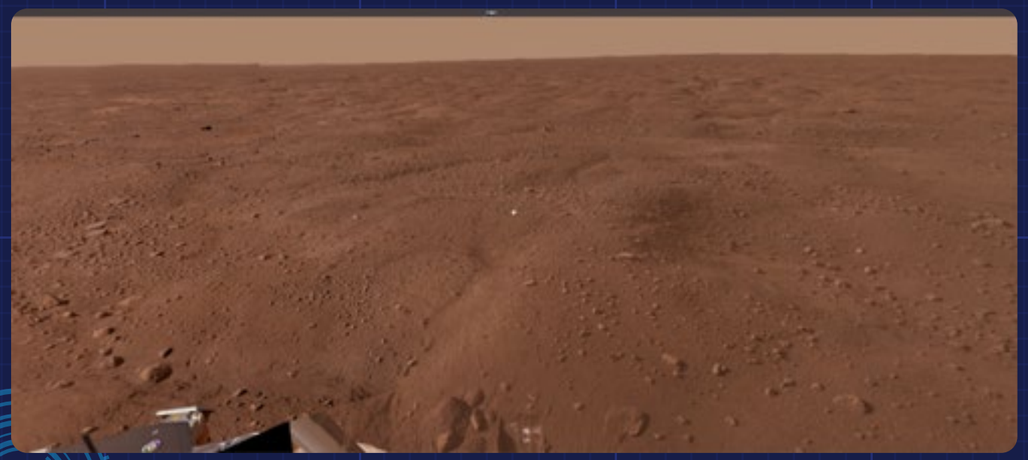
ACCESSIBILITY NOTE

A text description is provided and can be read to students by an educator or through a screen reader.

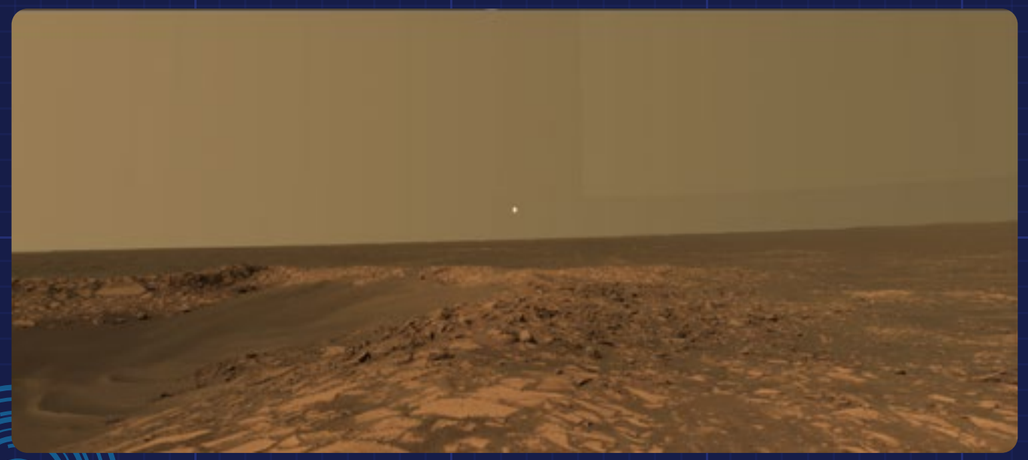
view images **visit WorldWide Telescope**



IMAGES FROM MARS LANDERS



PHOENIX LANDING SITE
view larger photo



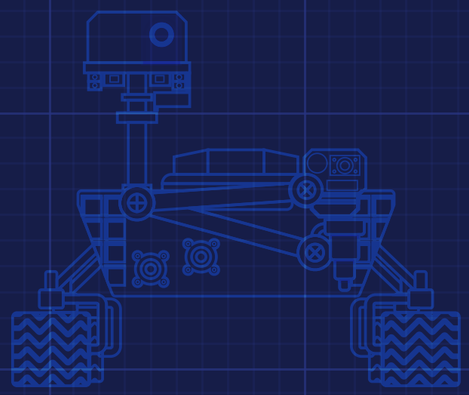
OPPORTUNITY BEAGLE CRATER
view larger photo

SPIRIT DESCENT FROM HUSBAND HILL
view larger photo

PERSEVERANCE FIRST PANORAMA
view larger photo

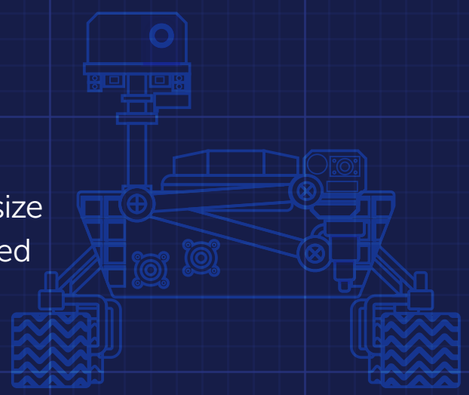
PHOENIX LANDING SITE

A wide shot of the Martian landscape where Phoenix landed. Mostly flat ground with small pebbles up to orange sized rocks, all a rusty orange color. The sky is a light brown to orange shade. The bottom of the image shows pieces of the Phoenix lander and a small spot where the upper inch of soil was scraped away revealing patches of white.



OPPORTUNITY BEAGLE CRATER

Shows a mostly flat landscape in the distance. Closer to teh camera are light brown to orange flat rocks between a few inches in size to several feet in size embedded in dark brown soil. From the to the left edge to the middle is a depression in the landscape covered in a fine dark brown sandy soil. Near the edge of the depression are small chunky rocks. The sky looks light brown to orange.



SPIRIT DESCENT FROM HUSBAND HILL

A landscpe that shows a hill ascending from the center of the image to the right edge. Light brown to orange colored fine sandy dirt covers the landscape. There are many dark grey rocks ranging in size from a few inches to a a few feet in size scatter across the hill. In the distance more hills are seen in silhouette on the horizon. The sky is a light orange color.

PERSEVERANCE FIRST PANORAMA

A dark brown hilly landscape. Mostly dark brown sandy dirt covering the ground with some small rocks to small boulders dotting the landscape, all dark brown. The sky looks white with a pink to orange color at places. Right hand side of the mage shows parts of the Perseverance rover.

ACTIVITY 2:

EXPLORE MARS ON STELLARIUM

TIME REQUIRED: **3 MINUTES**

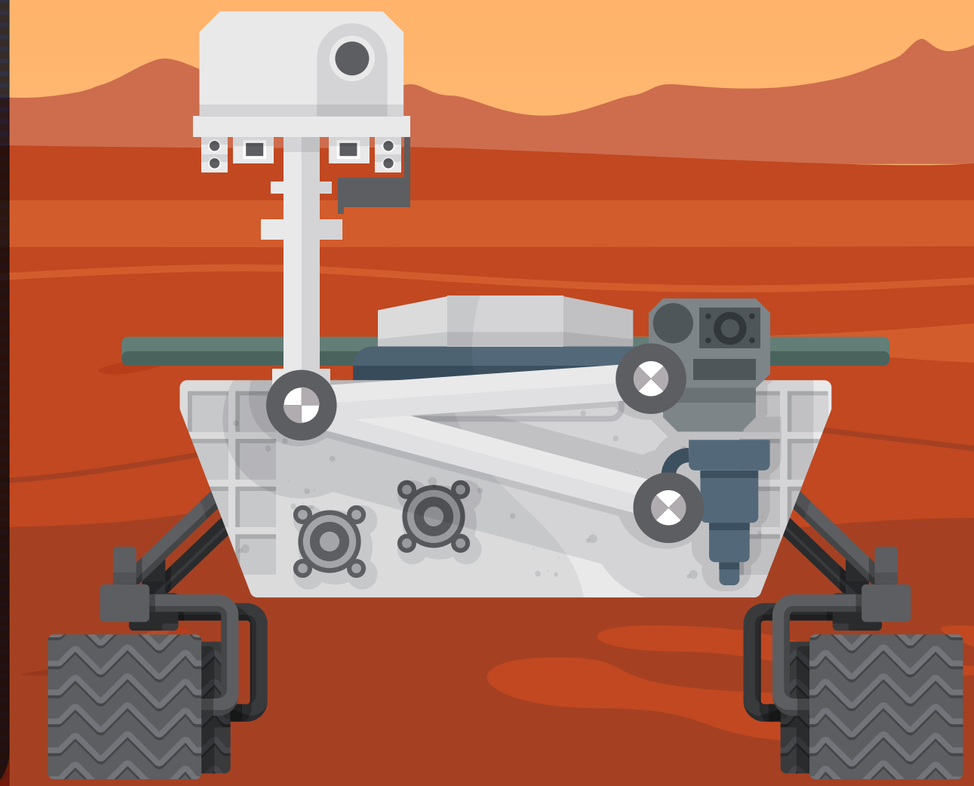
Have students explore what it would look like on Mars through a whole day using Stellarium screenshots or using the Stellarium software.

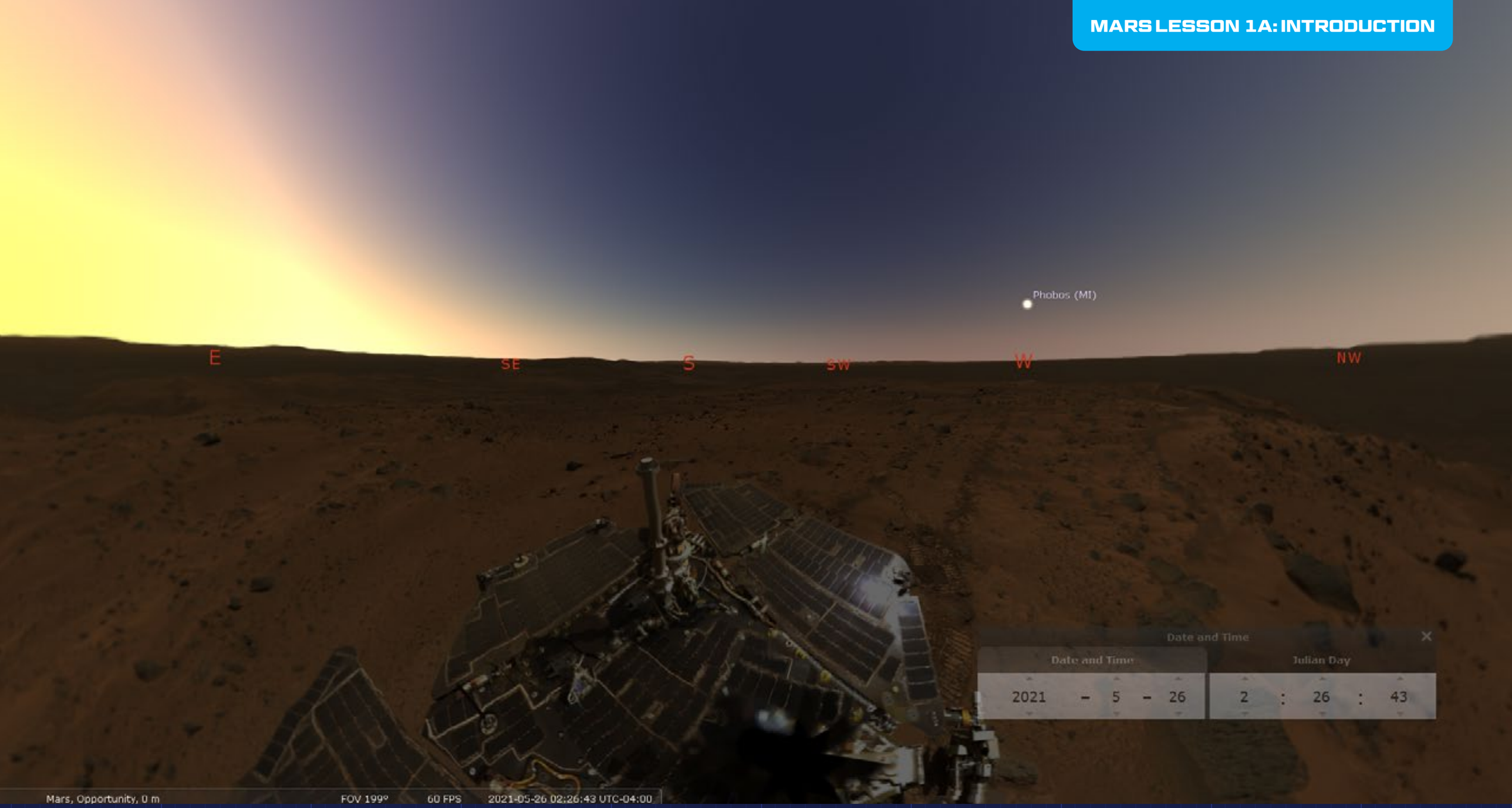
Show them the day and night cycle on Mars, and point out the moons Phobos and Deimos, the sun, Earth, and other planets.

ACCESSIBILITY NOTE

A text description is provided and can be read to students by an educator or through a screen reader. If using Stellarium software, describe what is happening on the screen.

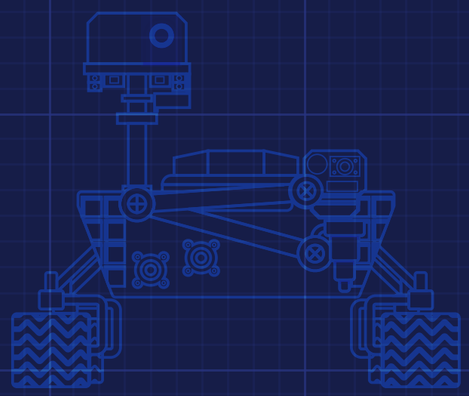
view images **visit stellarium**

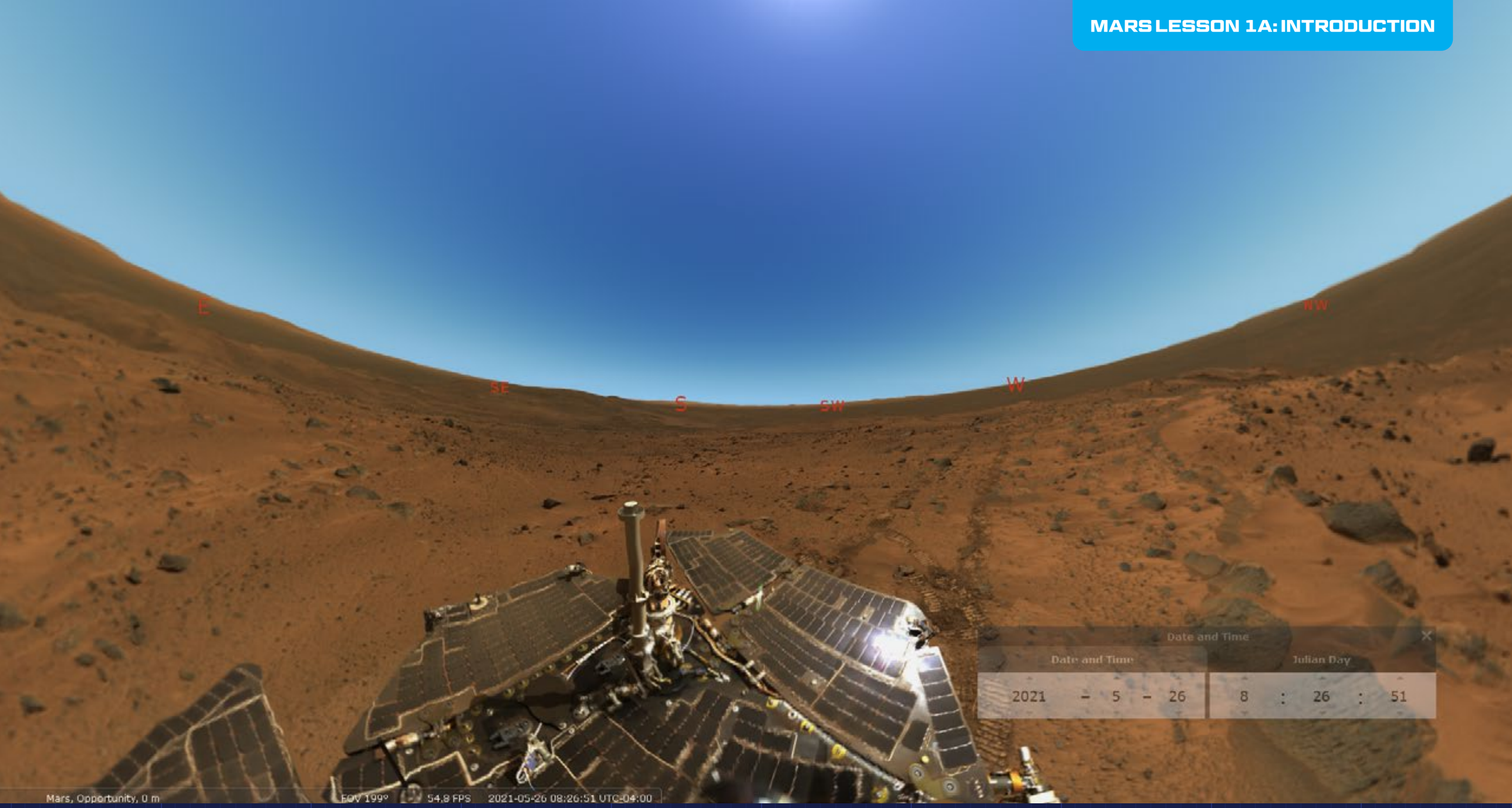




MARS - SUNRISE

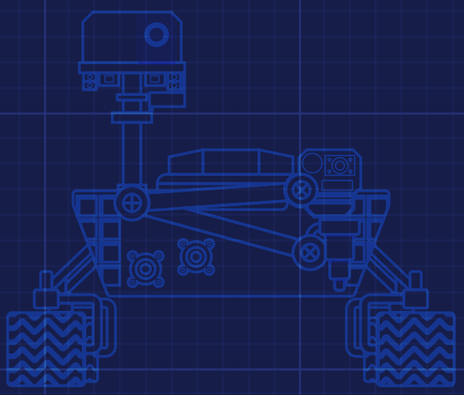
Shows a wide-angle view of Mars. E is on the left, S is center, W to the right of the image. Bright glowing is seen on the left. A bright dot is is seen near the horizon near the W labeled Phobos (M). Date is noted as 2021-05-26 and time is noted at 2:26:43.

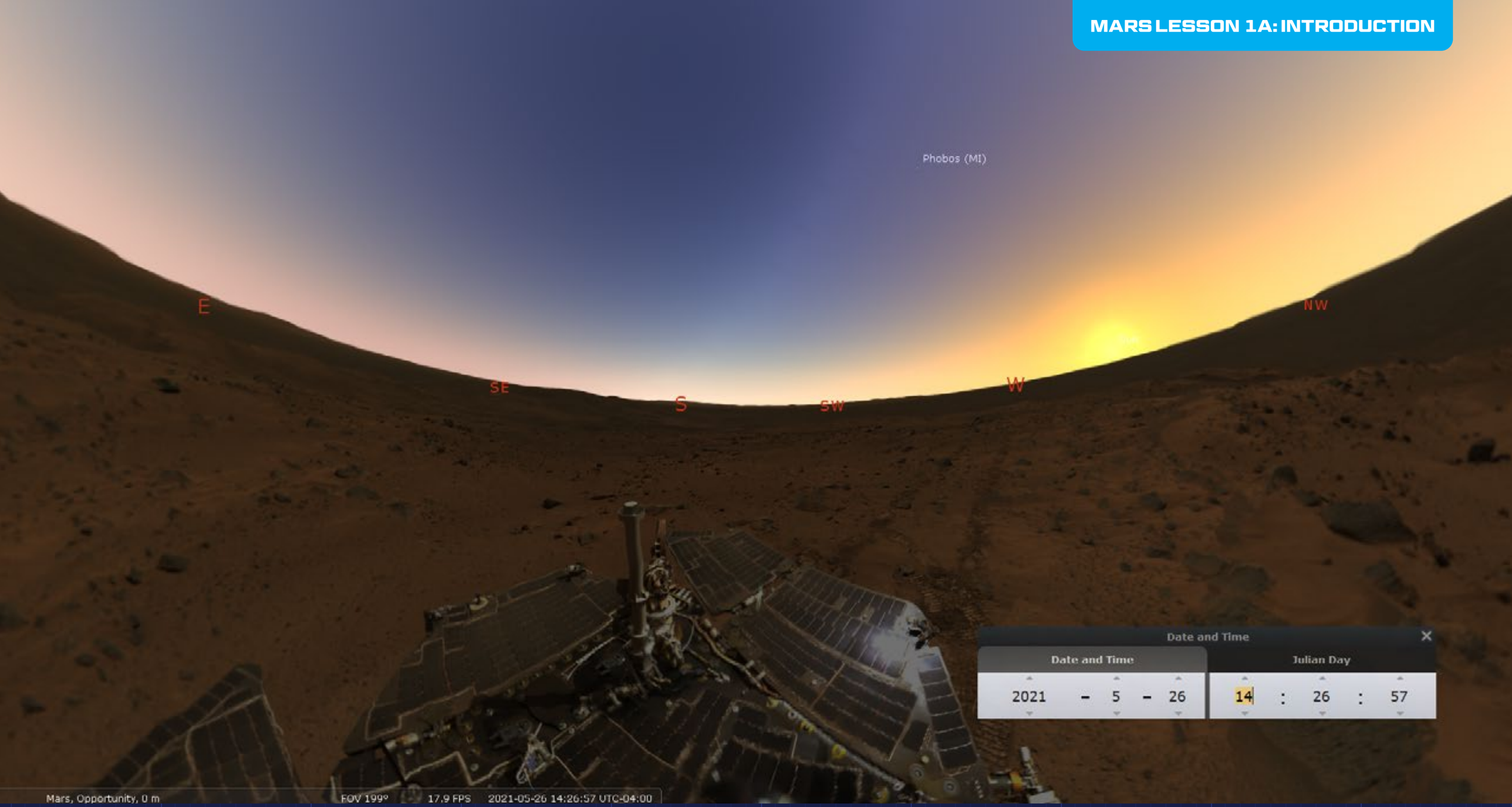




MARS - MIDDLE OF THE DAY

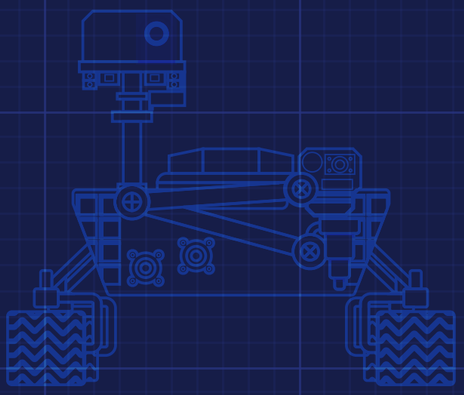
Shows a wide-angle view of Mars. E is on the left, S is center, W to the right of the image. Bright image of the sun is near the top of the image in the middle. Date is noted as 2021-05-26 and time is noted at 8:26:51.

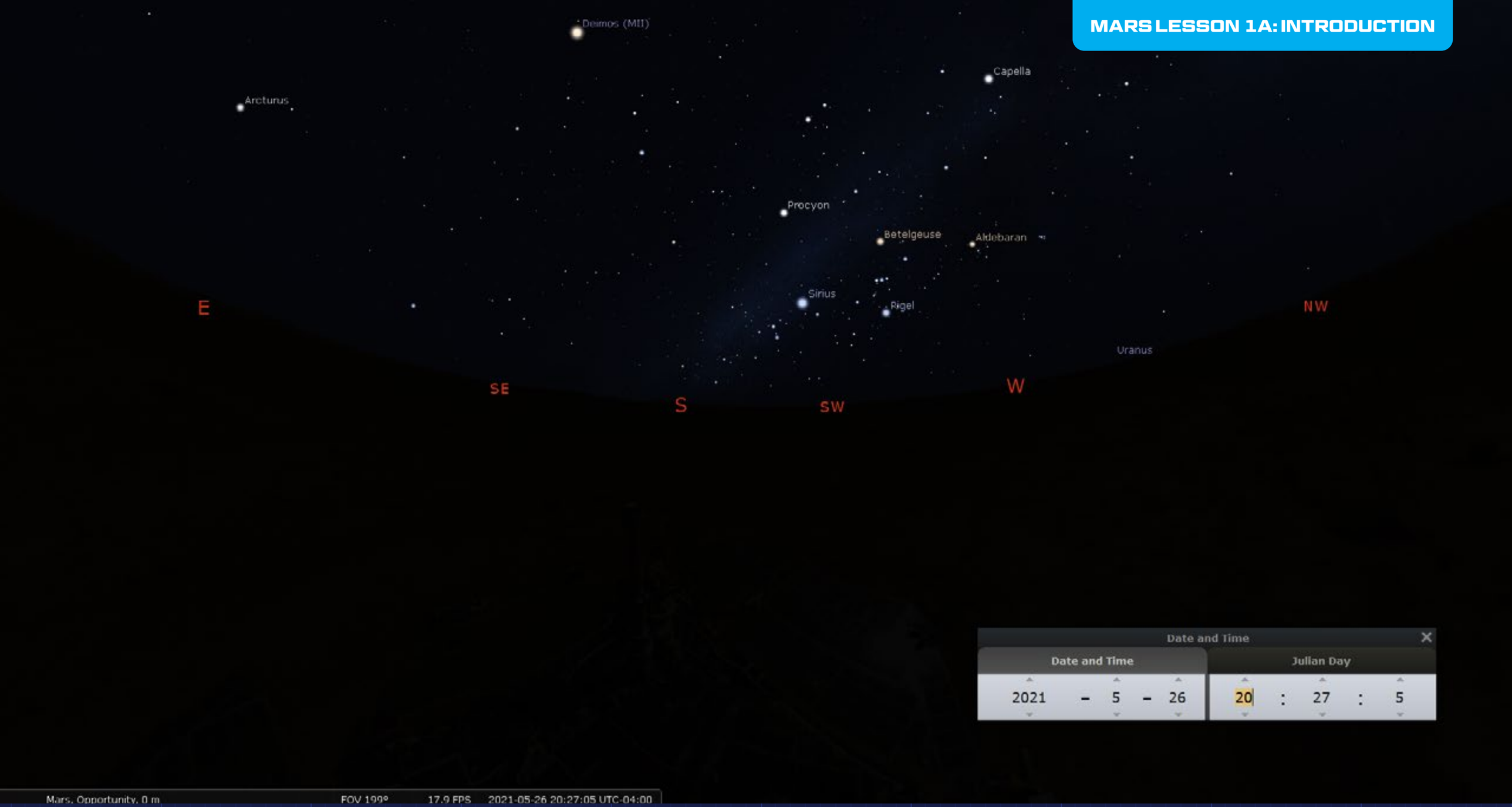




MARS - END OF DAY

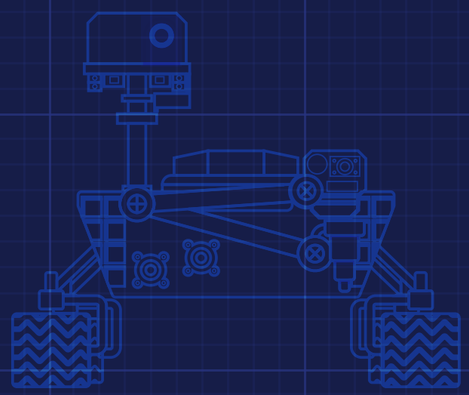
Shows a wide-angle view of Mars. E is on the left, S is center, W to the right of the image. Bright glowing is seen on the right. A pale dot is is seen midway up the sky over SW and is labels Phobos (M). Date is noted as 2021-05-26 and time is noted at 14:26:57.

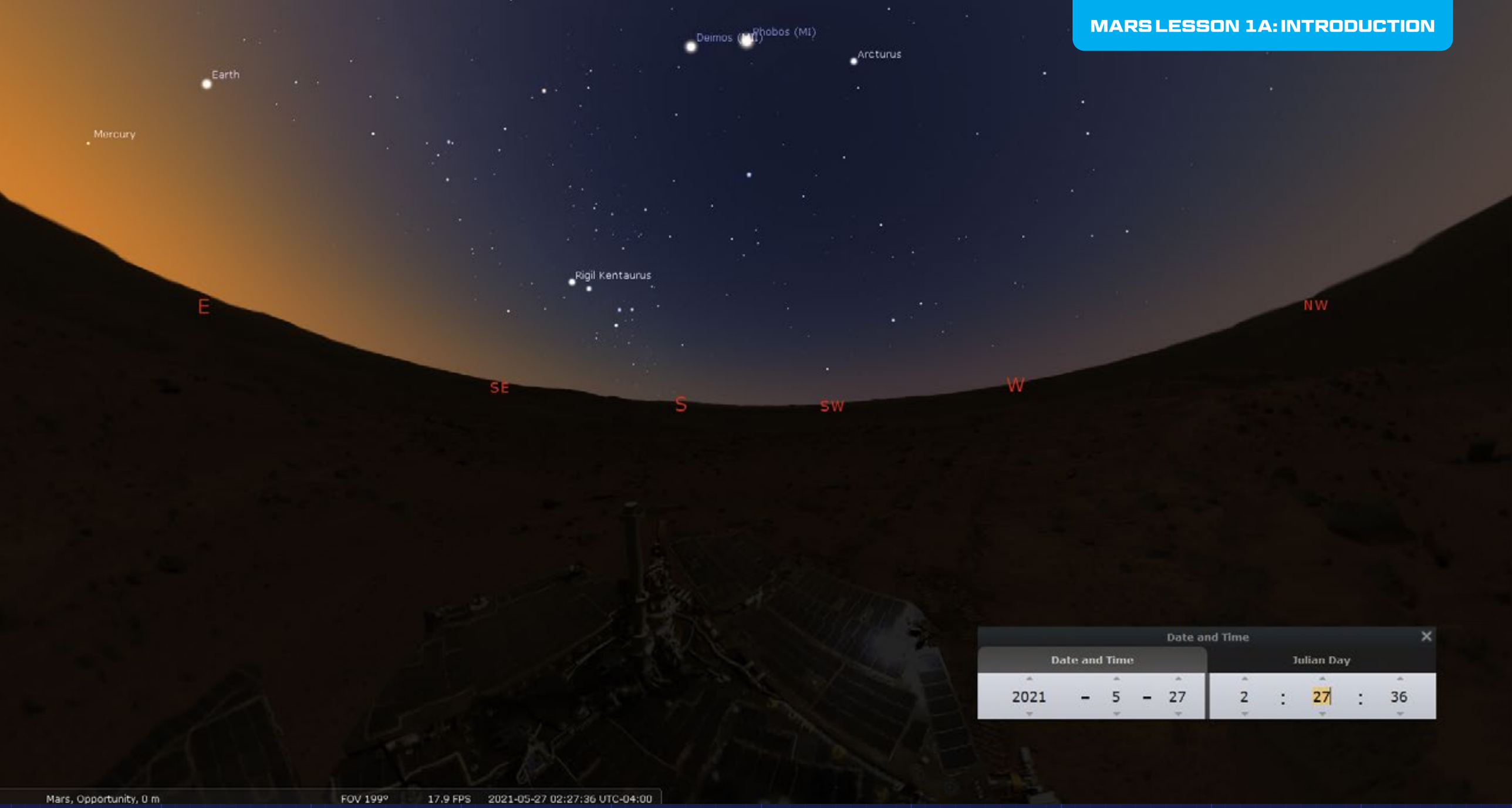




MARS - MIDDLE OF THE NIGHT

Shows a wide-angle view of Mars. E is on the left, S is center, W to the right of the image. Bright glowing is seen on the left. stars are seen and bright stars are labeled as Betelgeuse, Rigel, Aldebaran, Capella, Sirius, Procyon, and Arcturus throughout the sky. A dot is is seen near the horizon near the SE labeled Deimos (MII). Date is noted as 2021-05-26 and time is noted as 20:27:05.





MARS - SUNRISE AGAIN

Shows a wide-angle view of Mars. E is on the left, S is center, W to the right of the image. Bright glowing is seen on the left. A bright dot is is seen midway up the sky above the S and is labeled Phobos (M). To the left is another bright dot labeled Deimos (MII). To the right of Phobos (M) is a bright star labeled Arcturus. On the left of the image is a bright dot labeled Earth. Lower and to the left is a fainter dot labeled Mercury. Date is noted as 2021-05-27 and time is noted at 2:27:36

DISCUSSION

TIME REQUIRED: **6 MINUTES**

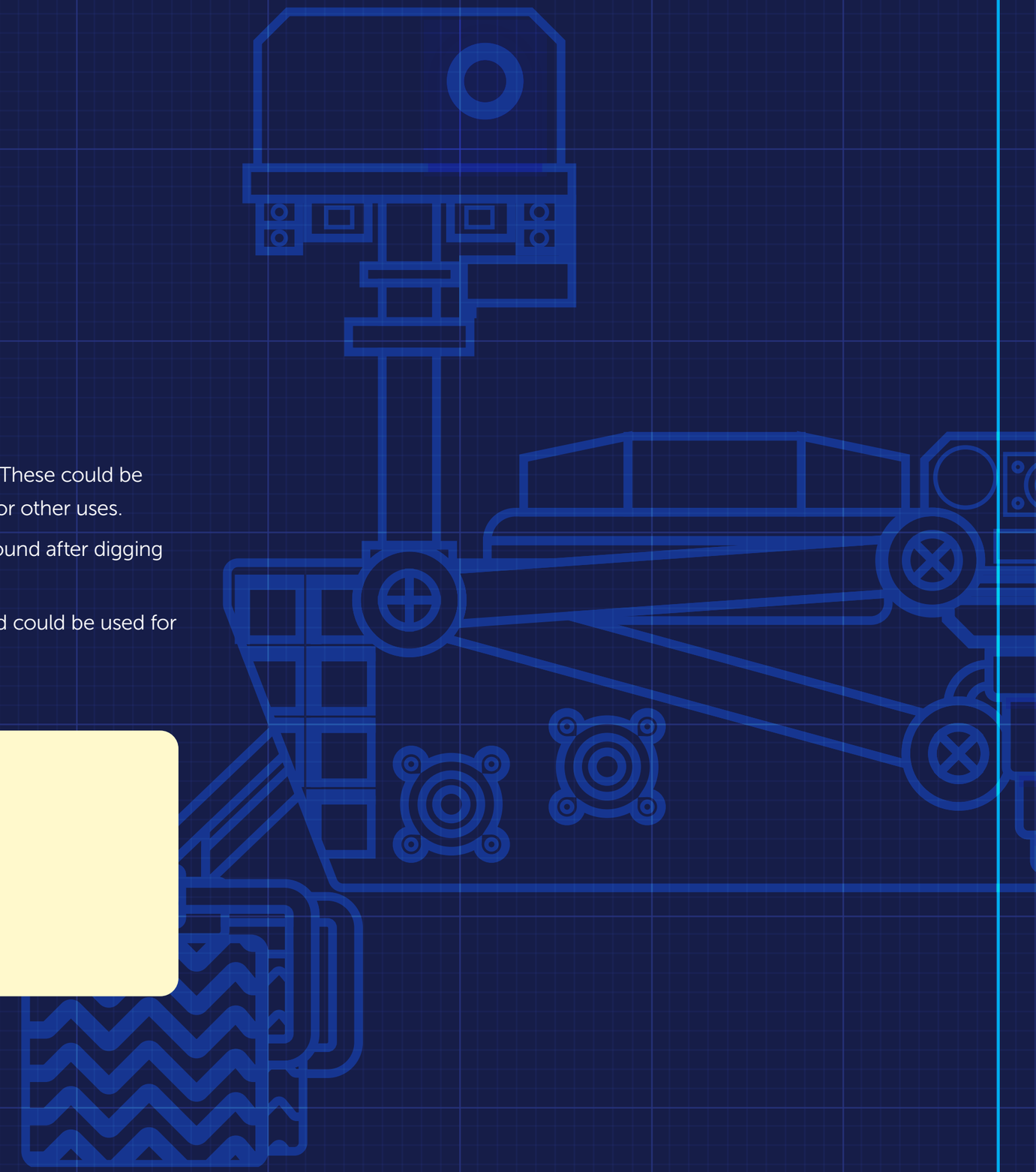
Ask students what they notice about Mars.

- How is it different from Earth?
- How is it the same as Earth?
- What resources appear to be available?
- Why should or shouldn't humans go to Mars?

Ask them to brainstorm their ideas and record them.

Some things to guide students toward would include:

- Noticing large boulders and rocks, or in other images, sandy or clay-like soil. These could be used as building materials or could be broken up into component materials for other uses.
- Pathfinder panoramas show a white substance which could be ice. Ice was found after digging under the surface by Pathfinder.
- Have students consider what is in the sky as well (e.g. the sun is still bright and could be used for solar power, existing satellites and rovers could be used).



NOTE TO TEACHERS USING WORLDWIDE TELESCOPE:

Some images have false colors. These are artificially enhanced to make it easy to distinguish different types of materials.

Some images are stereo, so if you have red and blue glasses they could pop out as 3D images.

OBSERVATIONS ABOUT MARS

SIMILARTIES	DIFFERENCES	AVAILABLE RESOURCES	WHY MARS?

View Google JamBoard

View Printable Worksheet

DEBRIEFING

TIME REQUIRED: **2 MINUTES**

Explain that Mars is a very interesting and exciting planet, and the one that is the most like Earth, and so it is a fascinating place to send humans next. There are plans to send humans there for long-term missions in our lifetimes. It is not without challenges, though. We are going to learn about the planet and how we can use its resources to build our own communities on Mars. We will combine what we know about Mars with urban planning so the students can build their own towns/cities/etc. on Mars.

URBAN PLANNING LESSON 1A:

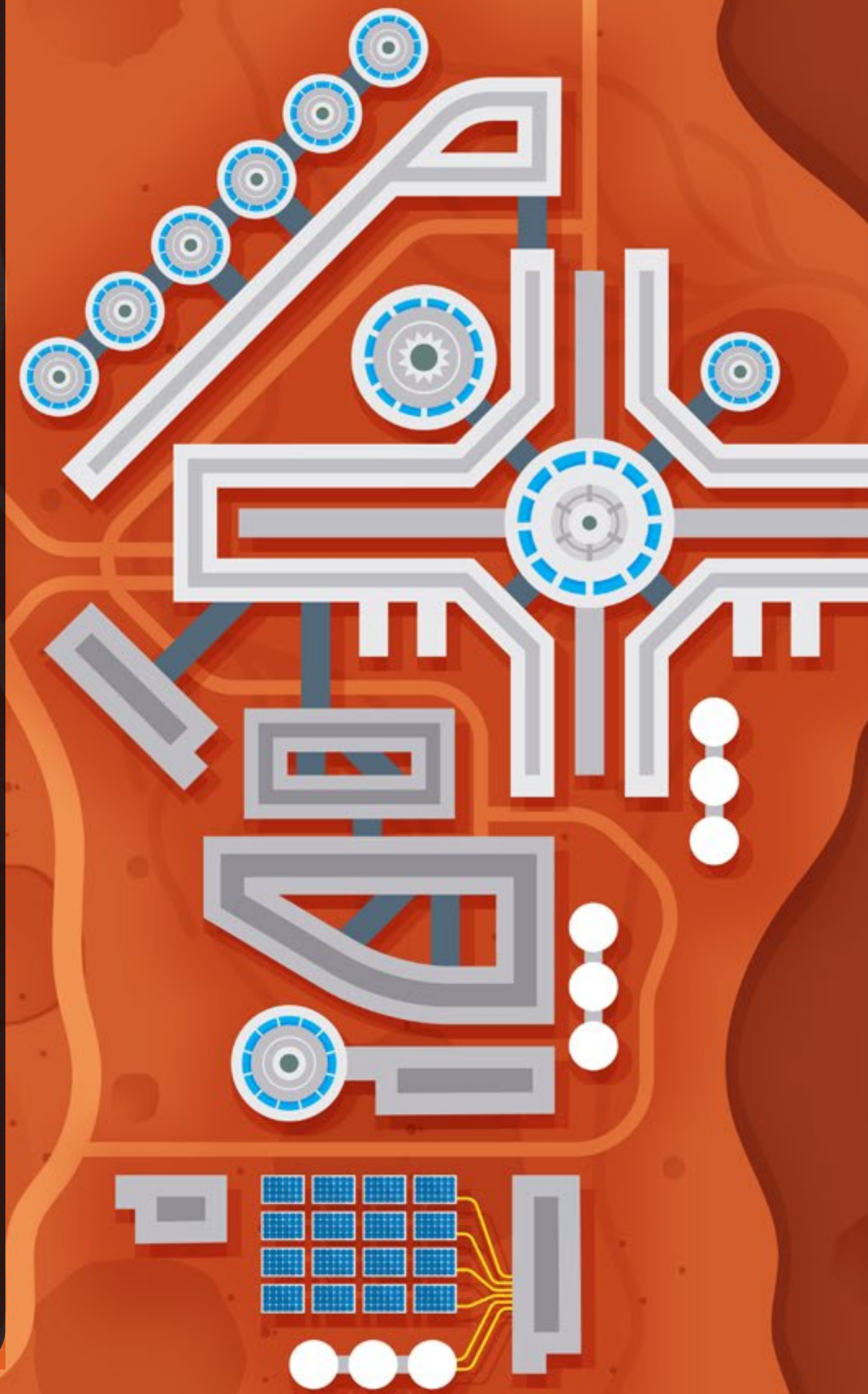
INTRODUCTION

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Define “urban planning”
- Define “urban planner”
- Name at least two things urban planners do
- Be able to state that the work planners do is based on laws



MATERIALS NEEDED

- **“Fun Challenge” questions**
  (listed in lesson)

- **Paper and pencil**
  (or other equivalents)

- **Image of East Lansing, Michigan**
  Grand River Avenue in East Lansing by GD333 is licensed under CC BY-SA 4.0

- **Image of “Three Neighborhoods”**
  Image by Robert Steuteville. Used with permission.

- **Access to internet to watch “Cities Through Time” video**
  https://sos.noaa.gov/datasets/cities-through-time

ACTIVITY:

WHAT IS URBAN PLANNING?

TIME REQUIRED: **15 MINUTES**

- **Fun Challenge**
  Put up the "Fun Challenge" questions on a screen and/or read students the questions. Have them write their answers on paper (or other equivalent) and ask them to share their answers at the end.

- **Share Information with Students**
  Ask students: "What if new buildings were built anywhere? What if there weren't enough parks and open space to break up the spaces between buildings? What if roads just criss-crossed each other any which way?

- **Watch Science On a Sphere® Show about Cities**

- **Homework: Explore More about Urban Planning**

FUN CHALLENGE

Put up the "Fun Challenge" questions on a screen and/or read students the questions. Have them write their answers on paper (or other equivalent) and ask them to share their answers at the end.

start challenge

FUN CHALLENGE:

QUESTION 1

TRUE OR FALSE:
PEOPLE DESIGNED THE CITIES WE LIVE IN?

view answer

FUN CHALLENGE:

QUESTION 2

URBAN PLANNERS ARE:

A: A NEW MUSIC GROUP

B: PEOPLE WHO PLAN TOWNS AND CITIES

C: POLICE OFFICERS

D: LOCAL PARK EMPLOYEES

view answer

FUN CHALLENGE:

QUESTION 3

TRUE OR FALSE:
PEOPLE CAN USE LAND HOWEVER THEY WANT?

view answer

SHARE INFORMATION WITH STUDENTS

Ask students: "What if new buildings were built anywhere? What if there weren't enough parks and open space to break up the spaces between buildings? What if roads just criss-crossed each other any which way?

Ask students for word suggestions:
"What words might you use to describe this place?"

That city might be a mess! Although it's not something we think about every day, the location of buildings, parks, roads, and public transit are planned. **Planning** is a process of decision-making, allowing cities and communities to meet the needs of all people in the most efficient way. (City By Design)

Show image of East Lansing, Michigan.

This is an image of East Lansing, Michigan. This small city was founded in 1839. Ask students: "What do you see in this picture that makes you think this city is a planned place?"

East Lansing is a planned city. All the spaces we live in are planned. Urban (or city) planning is something cities and towns do to make sure their places are safe and meet people's needs. Urban planning is about creating good places for people. Urban planning is a career, done by people called urban (or city) planners. They work for cities, states, and other governments. It is a job we are going to learn about — and something you could do someday, if it interests you. In this project, you will be "Martian urban planners"!

Show "Three Neighborhoods" image.

Urban planners work on many things, like places for people to live and work, transportation, government, culture, and more. Let's look closely at this image. You can see that the way places are designed changes over time. Ask students: "What kind of a neighborhood do you live in? Does it look like any of these pictures?"

Urban planners deal with what is happening now in places, but they also look forward to the future: 5, 10, 20, or even 50 years ahead! Planners try to plan for how places will be developed or redeveloped. Urban planners try to imagine what things might be like in the future. Ask students: "Why might this be a hard thing to do?"

Urban planners communicate their ideas. Urban planners just can't come up with ideas and do them. The planners create options for plans that other people then decide on — a government group or others. Most cities have a planning commission or group that is in charge of developing and deciding on plans for their city.

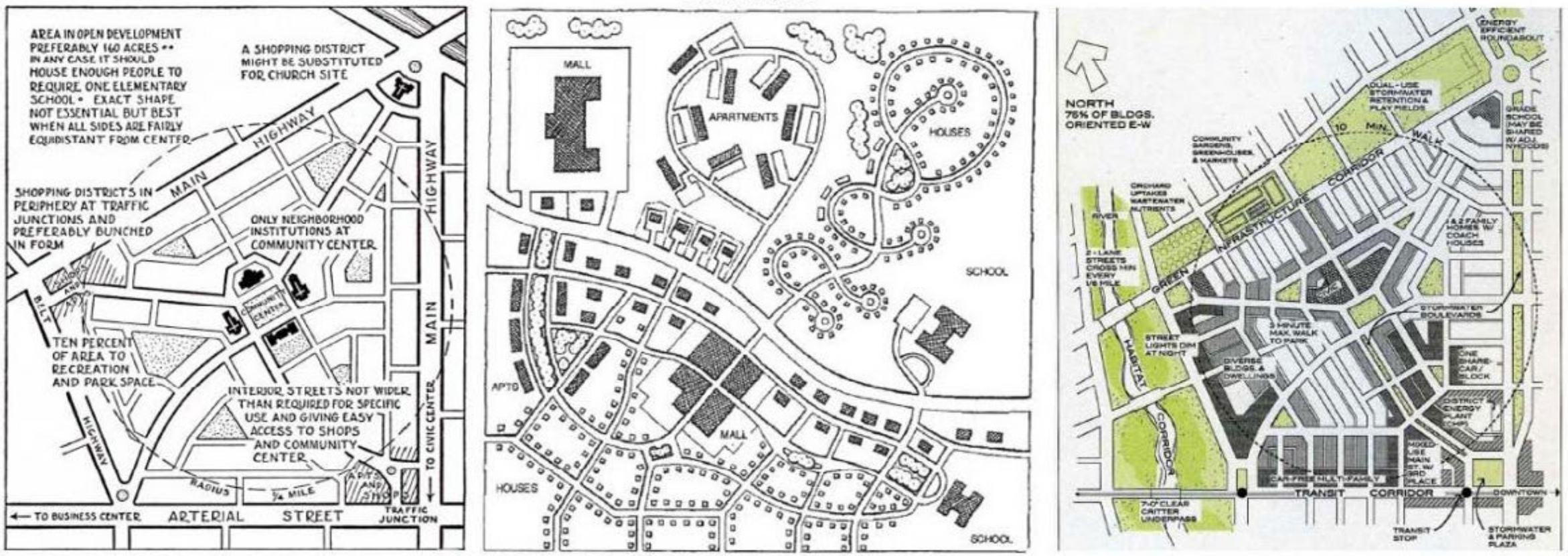
Urban planners care about places. They work together with others to imagine the future. They have to know about planning, plus laws and more. Because of laws, people have to use land in certain ways, and planners help them do that.

CITY OF EAST LANSING

This is an image of East Lansing, Michigan. This small city was founded in 1839.

Ask students: “What do you see in this picture that makes you think this city is a planned place?”

Neighborhood Organization



1930 1980 2008

Image by Robert Steuteville. Used with permission.

THREE NEIGHBORHOODS

Urban planners work on many things, like places for people to live and work, transportation, government, culture, and more. Let's look closely at this image. You can see that the way places are designed changes over time. Ask students: "What kind of a neighborhood do you live in? Does it look like any of these pictures?"

VIDEO:

SCIENCE ON A SPHERE® SHOW ABOUT CITIES

play video

Click on the play button above or the url below to open a web browser and play video:
https://sos.noaa.gov/catalog/datasets/cities-through-time

Internet access required to view video

HOMEWORK:

EXPLORE MORE ABOUT URBAN PLANNING

TIME REQUIRED: **5 MINUTES** + HOMEWORK

Urban planning is a career that involves many different kinds of skills and abilities. The following questions will help students explore the field of urban planning. Assign this as individual work or divide students into pairs or groups and assign each pair/group questions to investigate using online sources. Discuss the kinds of sources students should use

1. What different kinds of work do urban planners do?
2. What is an urban planner's work environment like?
3. What training do people need to become urban planners?
4. Who might like being an urban planner? Why?
5. What are some of the most famous accomplishments of urban planners?

Additional Resources

https://www.careerexplorer.com/careers/urban-planner

https://clas.wayne.edu/usp/programs/career-outlook

https://www.princetonreview.com/careers/162/city-planner

MARS LESSON 1B:

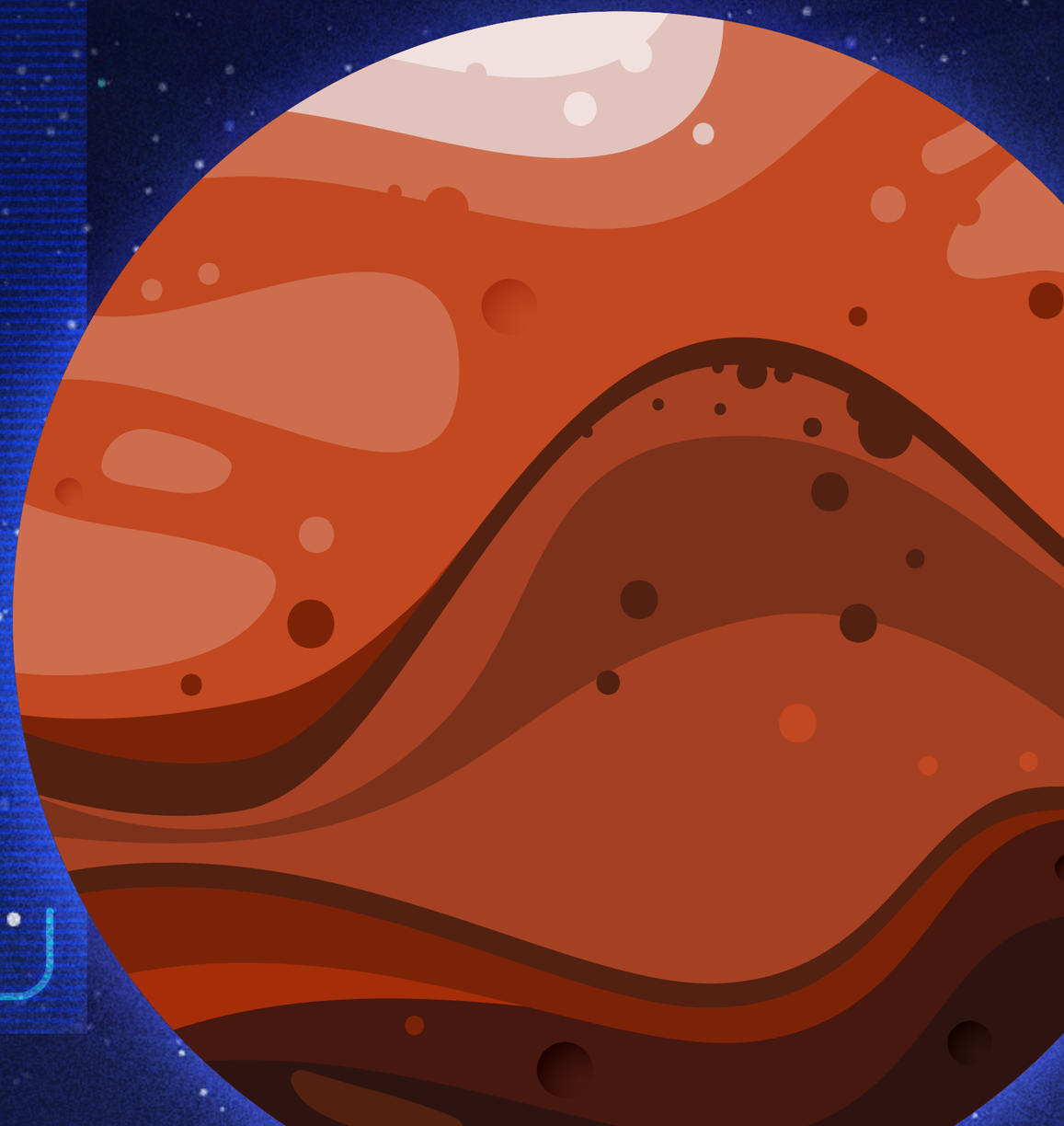
SURVIVE AND THRIVE

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Identify human needs to not only survive, but to thrive on Mars
- Students will think critically about structures needed to support those needs



MATERIALS NEEDED

- **Survive and Thrive Worksheet**
  or some other way to record ideas
  https://drive.google.com/file/d/1OCNavOsVjif3vAur1fhHw0DINHnNGb2s/view?usp=sharing

SURVIVE AND THRIVE:
INTRODUCTION

TIME REQUIRED: **3 MINUTES**

Explain to the students that we need to think about what we need to thrive on Mars. They will need to record the needs a human would have in order to *happily* live on Mars, and what sort of facility or infrastructure humans might need on Mars to meet that need. This corresponds to the first two columns of the Survive and Thrive worksheet. There may be several ideas or pieces of infrastructure that they may need. If students have questions and aren't sure what infrastructure is needed, that is okay. For the time being, have them note somehow that they are not sure. These ideas will be revisited later (in lesson 2A) along with whether or not they have what they need on Mars already (the third column of the worksheet).

Emphasize that they need to thrive on Mars and not just survive. They would need things that take care of physical health, and mental health as well! It's more than just food, water, and shelter. Have them think about what makes them happy in their city.

WHAT WOULD PEOPLE NEED TO THRIVE ON MARS?

TIME REQUIRED: **10 MINUTES**

Have students work in small groups to record their ideas.

Alternative: Model ideas by working through one or two ideas with the students.

POTENTIAL EXAMPLES:

- **Food is a need.** The infrastructure needed would be a farm, a kitchen, or gardens to ensure a variety of fresh food. This is an example of thriving vs surviving. They wouldn't be happy with pre-prepared astronaut food for long! They would want freshly prepared food with a lot of flavor.
- **Shelter is a need.** The infrastructure needed could be a house, or a bedroom in a multipurpose space. A way this is about thriving is that they need personal space and room to stretch out.
- **Air is a need.** The infrastructure may be an air recycling unit, or an air purification unit that utilizes some air from Mars. Students may not come up with that. Questions to ask them could be:
  - What kind of air is on Mars?
  - How do we get clean air humans can breathe on Mars?
- **Water is a need.** The infrastructure needed could be a water storage tank, water filtration system, or ice extraction facility.
- **Ability to communicate with Earth is a need.** Infrastructure needed is radio dishes and satellites.
- **Entertainment is a need.** People would need means of relaxing and having fun through games, movies, etc. So the facility or infrastructure could be some personal private space, a gym, a library, etc.

WHAT DO WE NEED TO SURVIVE AND TO THRIVE ON MARS?

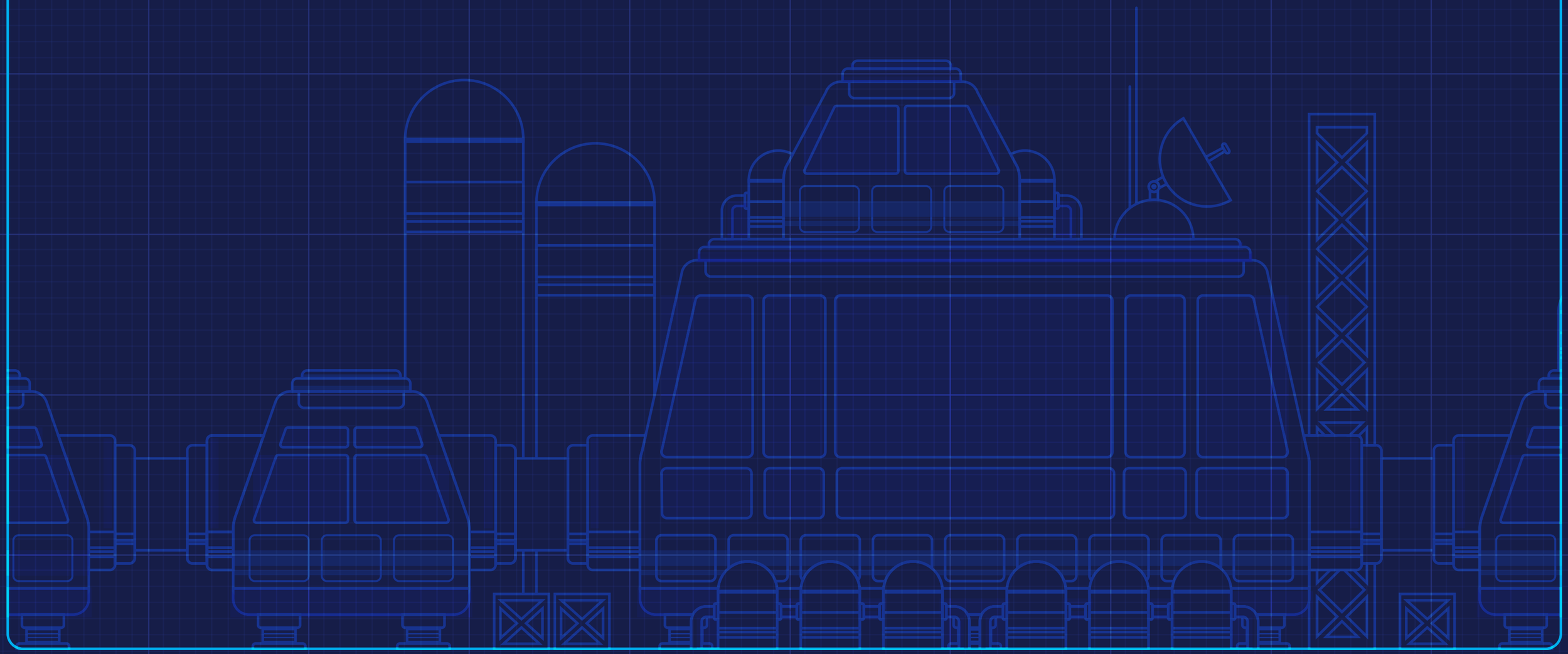
NEED	INFRASTRUCTURE	SOURCE

View Printable Worksheet

DEBRIEFING

TIME REQUIRED: **8 MINUTES**

Have student groups share an idea they had for a need and a piece of infrastructure that goes with it. See if other groups also thought of that need and had any different infrastructure ideas. Continue this for several items. This will give students a chance to see infrastructure ideas and to recognize questions they might have as a class, to be addressed in Lesson 2B.



URBAN PLANNING LESSON 1B:

HOW TO DESCRIBE LAND

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Define “surveying”
- Describe how land in the United States has a legal description
- Use “National Map” and other software to locate their school and other places

MATERIALS NEEDED

- **Access to “Surveyors Career Video”**
  https://www.careeronestop.org/videos/careeronestop-videos.aspx?videocode=17102200

- **Access to image “Members of the United States Geological Survey measuring a baseline near Fort Wingate, N.M., 1883,” showing old surveying equipment**
  https://www.loc.gov/resource/ppmsca.23728

- **Access to “National Map” software online**
  https://viewer.nationalmap.gov/advanced-viewer

- **Optional teacher resource sheet with PLSS example - “Maps Graphics PLSS”**
  https://project.geo.msu.edu/geogmich/michigan/Maps_Graphics%5CUSPLSS.pdf

REVIEW FROM LAST SESSION

TIME REQUIRED: **4 MINUTES**

Review what urban planning is. What do they remember from last time? What do urban planners do? Why is urban planning important now, and for the future?

ACTIVITY 1:

LAND DESCRIPTIONS IN THE UNITED STATES

TIME REQUIRED: **10 MINUTES**

Land use in the United States is based on legal descriptions and zoning laws, which we will learn more about soon. Just like the address of where you live, each piece of land in the United States has a special legal description. To legally describe land, it needs to be surveyed. **What is surveying?** *[Take student responses]*

VIDEO:

SURVEYORS CAREER

play video

Click on the play button above or the url below to open a web browser and play video:
https://www.careeronestop.org/videos/careeronestop-videos.aspx?videocode=17102200

Internet access required to view video

Image Source: https://www.loc.gov/resource/ppmsca.23728/

MEMBERS OF THE UNITED STATES GEOLOGICAL SURVEY MEASURING A BASELINE NEAR FORT WINGATE, N.M., 1883

Of course, back in the 1800s surveying looked more like this! People surveyed so land could be given boundaries or property lines and legal descriptions. [Ask students] Based on what you know, why do you think legal descriptions are needed?

INTRODUCE DIFFERENT SURVEY SYSTEMS

Three types of land descriptions are used in the United States.

1. **Metes and bounds:**
   Uses local markers and land features to describe property lines. Descriptions can use natural features like trees and rivers or human-made things like roads, carved stones, or wood markers.

2. **Public Land Survey System** (PLSS)**, also known as the rectangular survey system:**
   Created by the Land Ordinance of 1785. Much of the country was surveyed this way, except for the 13 original colonies plus Maine, Vermont, West Virginia, Kentucky, Tennessee, and Texas. The PLSS created a grid that is still used today to legally describe land. To navigate to the grid, visit https://viewer.nationalmap.gov/advanced-viewer and follow the steps below:
   1. Click on the "Add Data" icon (+ sign) in the top navigation bar (5th from the left).
   2. Add the BLM Public Land Survey System (PLSS) layer.
   3. Start to zoom over your state on the map using "+" button on the left side of the screen.
   4. You will see a grid appear. Stop zooming when you see the numbers and letters appear in the grid.

3. **Lot and block** (plat or survey description)**:**
   A "subdivision" of land that is divided into "blocks" then into smaller units called "lots"

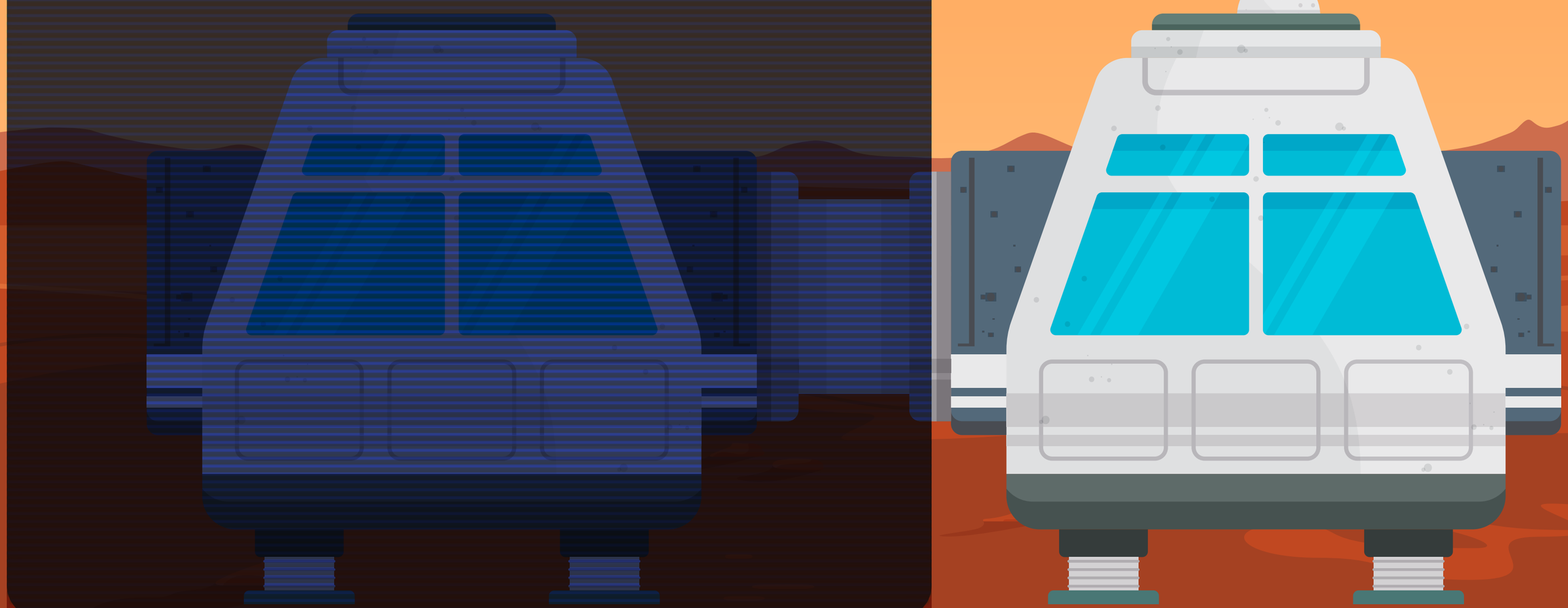
Some states and counties have parcel viewer systems, for example, North Carolina: https://www.nconemap.gov/pages/parcels

ACTIVITY 2:

FIND YOUR SCHOOL

TIME REQUIRED: **6 MINUTES**

Together as a class, or individually, use the PLSS software (https://viewer.nationalmap.gov/advanced-viewer) or a state/local parcel viewer system to find your school. What can students learn from their school's land description?



MARS LESSON 2A:

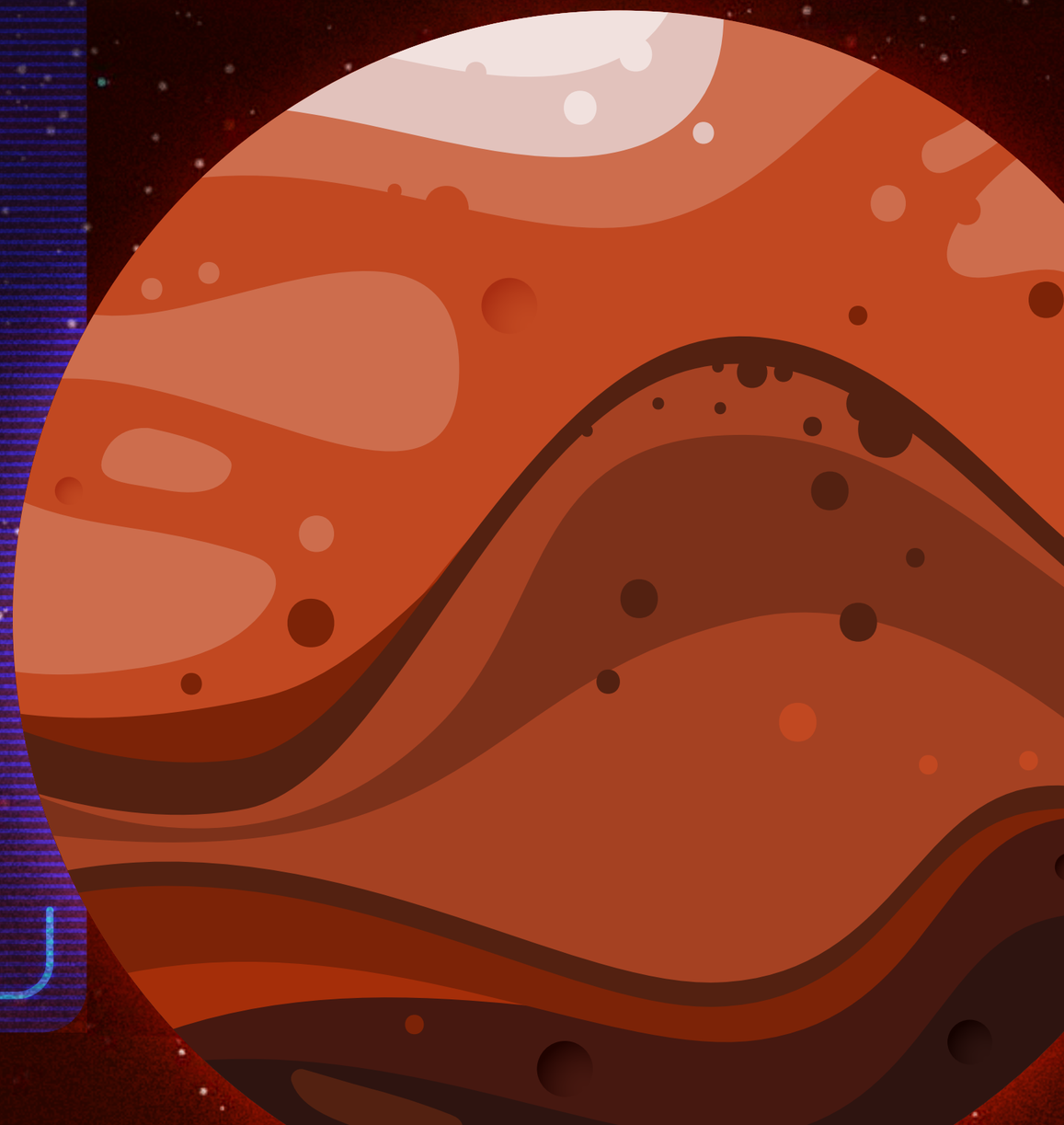
MARS OVERVIEW

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Identify challenges to living on Mars, including its location in the solar system
- Explain what the environment on Mars is like
- Brainstorm more infrastructure needed on Mars
- Think about what needs to be built or can already be used to be independent on Mars



MATERIALS NEEDED

- **Survive and Thrive sheet** or alternative method of recording ideas they started in the previous lesson
  - PDF version from previous lesson
- **Mars Overview Video** — this video can be shown to the students directly or used as a way of developing a more interactive lesson an educator leads.

VIDEO:

LESSON ABOUT MARS

play video

Click on the play button above or the url below to open a web browser and play video:
https://mediaspace.msu.edu/media/Mars+Basics/1_n84kdn07

Internet access required to view video

VIDEO OR LESSON ABOUT MARS

TIME REQUIRED: **20 MINUTES**

The “Mars Overview” video that is provided delivers basic information about Mars. Either have students watch that video or use it as a basis for your own lesson on Mars. These general topics are covered in the video and should be emphasized during a lesson.

- Location in the solar system and what that means for supply missions. Emphasize that much material needs to be grown/found/produced on Mars because supply missions can only be sent every 2 years.
- Light travel time and how that impacts communication.
  [*PAUSE video for a timer activity]*
  Alternative: Pause video for a timer activity. Encourage students to set a timer on their phone for 8 minutes and for 40 minutes.This is to emphasize the amount of time they would need to wait for a response from Earth to reach Mars if they send a communication. Older students or students who are remote can do this on their own devices. For younger students or students in the classroom, the teacher can set these timers.
- Length of Martian day and year. Emphasize similarities between Earth and Mars and the potential for solar power. Also touch upon what the sun looks like from Mars (not as bright from Mars as from Earth) and that Mars is generally a lot colder. Discuss global temperature ranges for Mars (from about –120 to 70 F). This will have been addressed on day one in the Stellarium view of the Martian day, but reiterate it briefly here.
- The Martian atmosphere’s thickness, atmospheric pressure, and dust storms and how those are a problem, especially for solar power.
- Regions of Mars and their different temperatures. Touch upon the general types of soil, and that there are seasonal and latitude differences—just like Earth, Mars is colder near the poles, warmer near the equator.
- Geological features including the type of rock, ice, and other materials available and how that compares to Earth. Note that different materials can be used in different ways (rocks can be used to make concrete, ice can be used for water but also split into hydrogen and oxygen, which can be rocket fuel).
- Radiation amounts on Mars
- Current satellites and robotic missions still in operation around Mars. Note that they are resources already available that it may be possible to repurpose for communication, and how that could help keep communication constant even when facing away from Earth.
- Health and ethical considerations about protecting Mars and the people there, including the risk of bringing germs from Earth.
- Current work being done to address the challenges of living on Mars. Discuss examples including habitats where analog astronauts live, hydroponic gardening, and ISS filtration systems.

ACTIVITY:

WHAT DO WE KNOW ABOUT MARS?

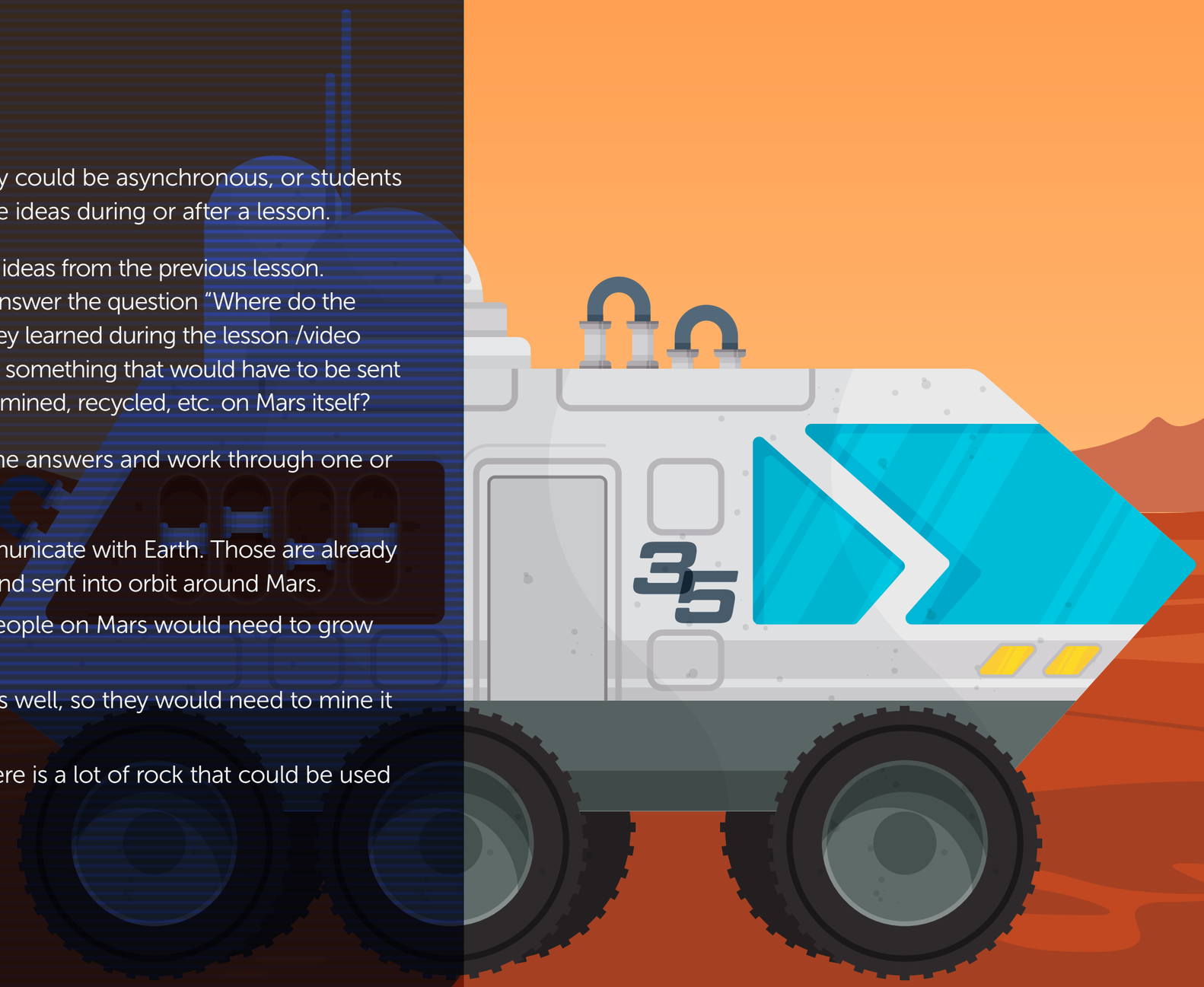
TIME REQUIRED: **20 MINUTES**

This can be done throughout the video. The activity could be asynchronous, or students can pause and do this, or give students time to note ideas during or after a lesson.

Have the students get out their method of recording ideas from the previous lesson. They will now consider their ideas from before and answer the question "Where do the resources come from?" Have them consider what they learned during the lesson /video and think of what need they will be able to meet. Is it something that would have to be sent from Earth in a supply mission, or could it be grown, mined, recycled, etc. on Mars itself?

Alternative: for younger students, model some of the answers and work through one or two ideas. Potential answers include:

- Communication will require satellites that communicate with Earth. Those are already at Mars. OR New ones could be built on Earth and sent into orbit around Mars.
- Food supply missions will be too difficult, so people on Mars would need to grow their own food on Mars in a farm facility.
- Water supply missions would be too difficult, as well, so they would need to mine it and/or recycle it on Mars.
- Shelter would need to be built on Mars and there is a lot of rock that could be used to build the facilities.



URBAN PLANNING LESSON 2A:

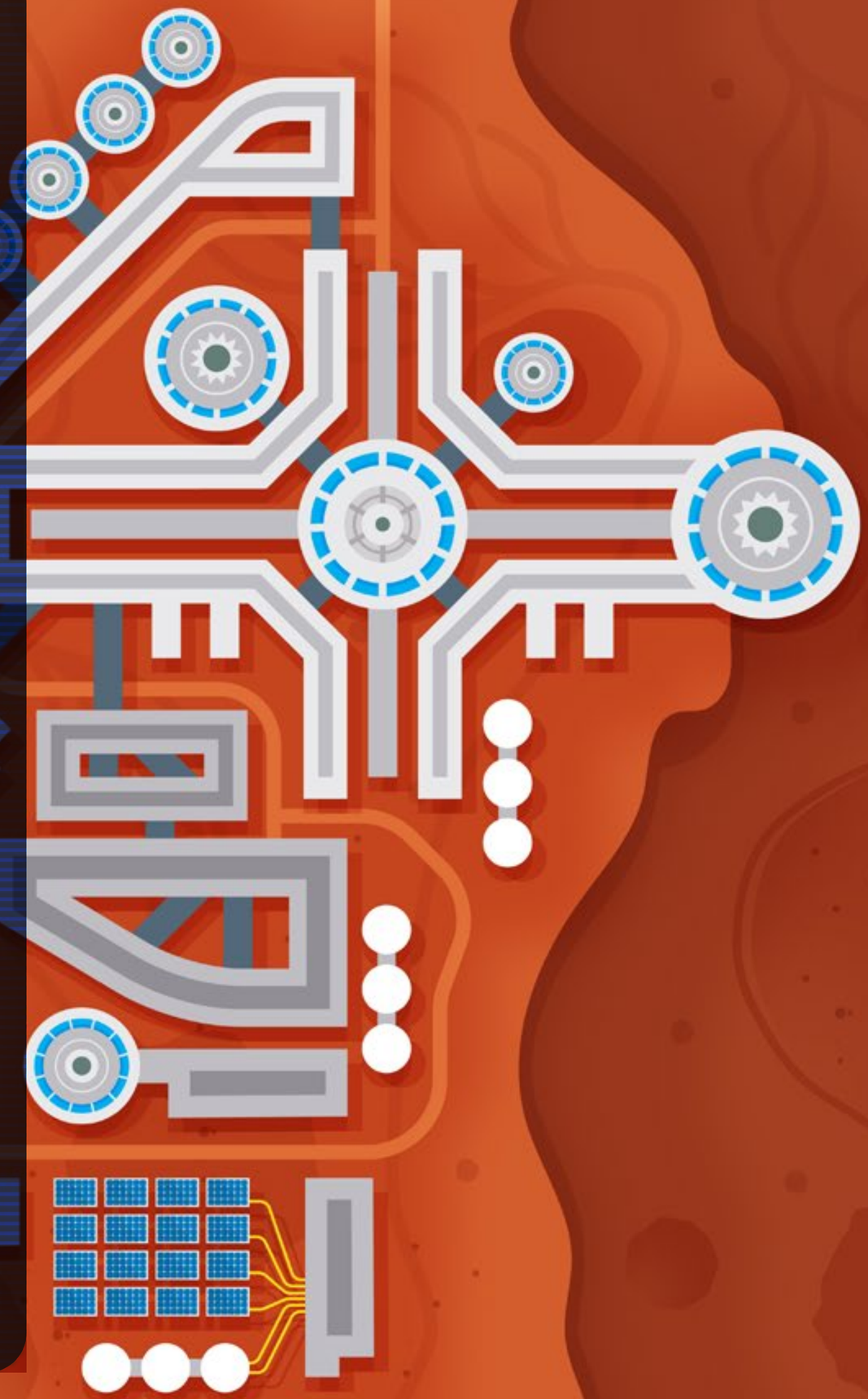
LAND USE PLANNING AND ZONING

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Define “land use plan”
- Define “zoning”
- Name at least four zoning categories
- Use zoning category names to discuss their community zoning map



MATERIALS NEEDED

- **Image of cartoon city**
- **Image of Sydney, Australia**
  Aerial View Chatswood to Sydney by Mark Merton is licensed under CC BY-SA 4.0
- **"Zoning Match Game" sheet**
- **"Zoning Categories" teacher sheet**
  https://drive.google.com/file/d/1P1zfqpHeYXiEP_ZaZlhG85n7SGrLxf54/view
- **"Zoning Categories" student sheet** (1 per student, printed or digital format)
  https://drive.google.com/file/d/1xRReHWo2-JpnTmYM0Ji7zFphVMQd1CEQ/view
- **Pencil or other equivalent** (optional)
- **Zoning map for school community**
  (Search online for your community's map. Most communities offer these maps for free on their city websites.)

REVIEW FROM LAST SESSION

TIME REQUIRED: **4 MINUTES**

What do students remember about land descriptions in the United States?

ACTIVITY 1:

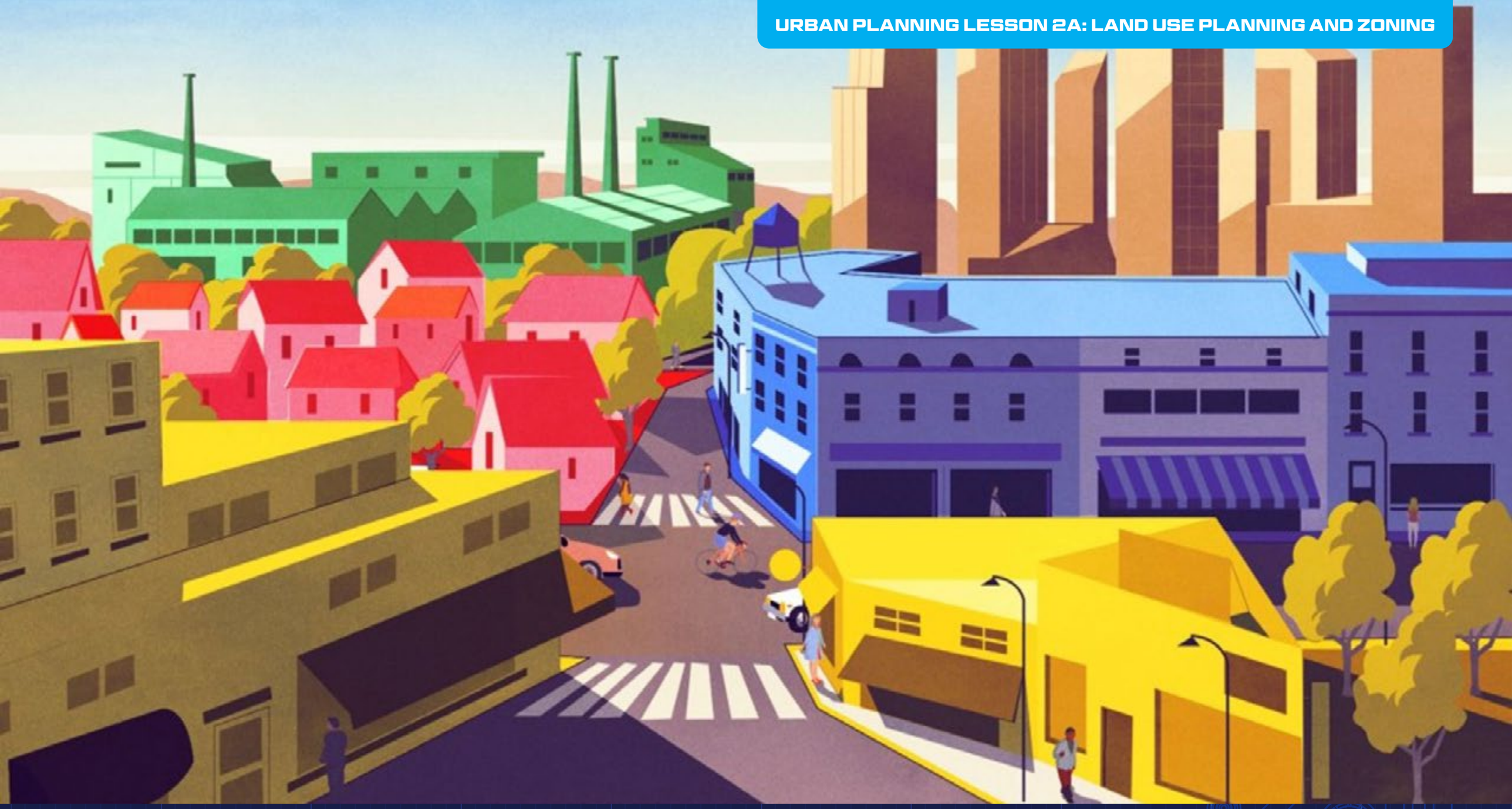
LAND USE AND ZONING INFO

TIME REQUIRED: **10 MINUTES**

Land use and urban planning is based on legal description and laws. People cannot use land any way they want.

A **land use plan** tells how land will be used in a community — the overall, umbrella plan for the city. Land can be assigned different purposes. The plan tells people what land can be used for what purposes. *[Ask students]* Can you think of some examples of land use in your community?

Zoning puts land use into categories. Zoning laws say where buildings can be built and how many kinds of buildings can be built. The laws can say how much space must be between different categories of buildings. You can't put a business in a residential area where people's houses and apartments are. You can't build a factory in a park area.



STARTING TO RECOGNIZE ZONING

[Ask students] Can you guess some of the zoning categories in this picture? What are the red buildings? Green? Yellow?

HERE'S WHAT ZONING LOOKS LIKE IN REAL LIFE

Aerial view of Chatswood, Australia, looking toward Sydney. The boundaries between low density residential, commercial and industrial zones are clearly visible. *[Ask students]* What do you notice in this picture?

When you start planning your Mars community, you will need to come up with a plan for what kinds of buildings are needed, plus what can go where.

ZONING MATCH GAME

Have students get out their "Zoning Categories" student sheet.

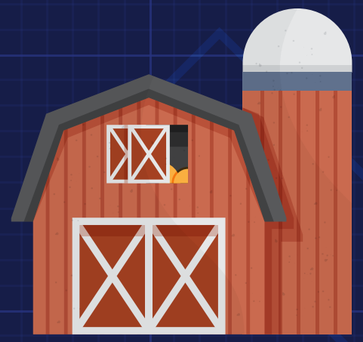
[Show document] Display the "Zoning Match Game" sheet on screen or write the seven category names on a board. Leave the document up while talking about the categories.

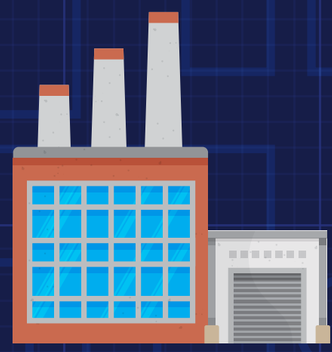
[Tell students] Let's look at seven different land use categories and see if you can match the zoning type to the pictures on your sheet. Write in the names of each category on your sheet as we talk about them.

ZONING MATCH GAME

Can match the zoning type listed below to the pictures on the right?

- RESIDENTIAL
- COMMERCIALTHINGS
- INSTITUTIONAL
- INDUSTRIAL
- PARKS/OPEN SPACE/ PUBLIC SPACE
- AGRICULTURAL
- MIXED USE





ZONING MATCH GAME DEFINITIONS

Talk about each of these categories with the students.
Have them name examples of each from their own community.

Click on a category title to show its definition.

- RESIDENTIAL
- COMMERCIAL
- INSTITUTIONAL
- INDUSTRIAL
- PARKS/OPEN SPACE/PUBLIC SPACE
- AGRICULTURAL
- MIXED USE

Reset Game

ACTIVITY 2:

EXPLORE COMMUNITY ZONING MAP

TIME REQUIRED: **6 MINUTES**

Let's look at a zoning map for your community. *[Ask students]* What do you notice? Using zoning category names you learned today, tell where land use categories are allowed. Why do you think things are this way?

HOMEWORK:

CREATE A LAND USE PLAN

Draw a rough draft of a land use plan for your Mars community.
Use what you learned today to label land use areas.

MARS LESSON 2B:

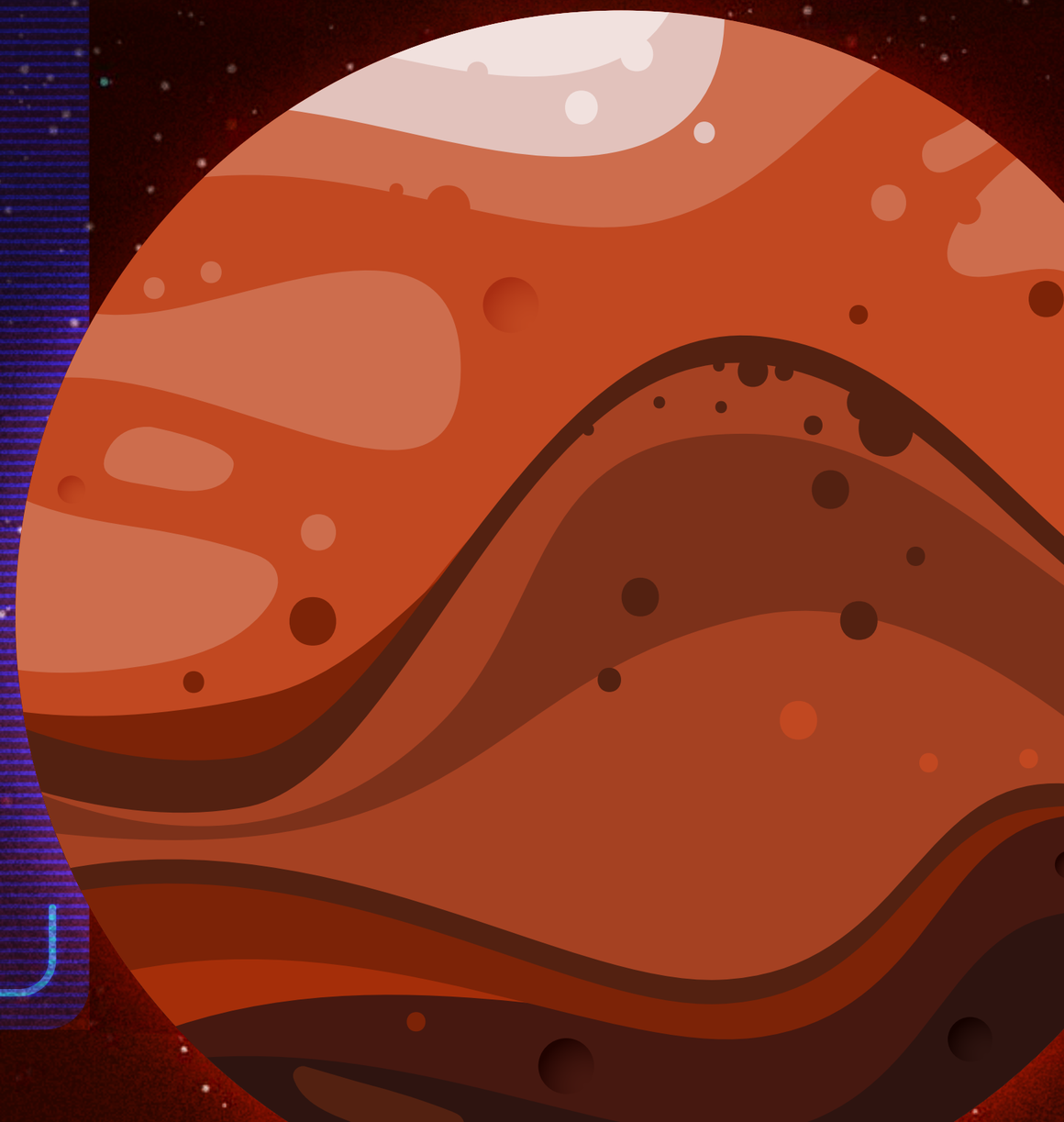
HABITAT DESIGNS

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Identify pros and cons of different habitat environments
- Identify new considerations about how to build their own buildings on Mars



MATERIALS NEEDED

- **Videos from NASA 3D printed Martian habitat competition**
  - **MARSHA**
    https://www.youtube.com/watch?v=XnrVV0w2jrE
  - **ZOPHERUS**
    https://www.youtube.com/watch?v=ITNqPhrCpdM
  - **NORTHWESTERN**
    https://vimeo.com/270669777

- **Habitat Design Evaluation sheet**
  or some other way to record ideas about the pros and cons of each design
  https://drive.google.com/file/d/1akcQwOCBenAEW98Dgjx9C47lOd1JhHhd/view?usp=sharing

- **Vocabulary sheet** (optional)
  https://drive.google.com/file/d/1j2IgpcbbWn8FGMmFineZJ644II36iGnZ/view?usp=sharing

- **Video** (optional)**, "What Is 3D Printing and How Does It Work?"** (2:21)
  https://www.youtube.com/watch?v=Vx0Z6LplaMU

ACTIVITY 1:

MARS HABITAT DESIGN VIDEOS

Have students watch the three videos. Before starting, explain that NASA hosted a competition that asked teams to design buildings or habitats that could be 3D printed using materials on Mars. These materials are referred to as **indigenous materials**.

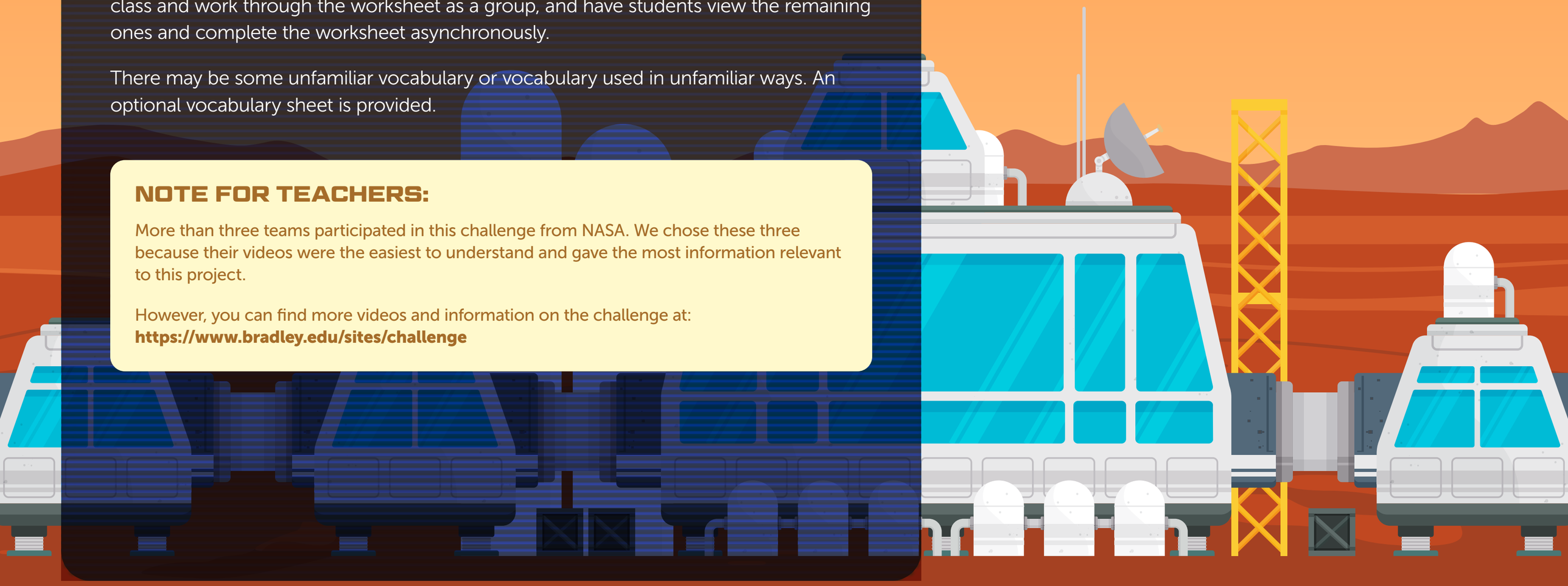
Alternative: If time is an issue, choose just one or two instead. If only choosing one, we recommend MARSHA, the one that won the competition. You could watch one as a class and work through the worksheet as a group, and have students view the remaining ones and complete the worksheet asynchronously.

There may be some unfamiliar vocabulary or vocabulary used in unfamiliar ways. An optional vocabulary sheet is provided.

NOTE FOR TEACHERS:

More than three teams participated in this challenge from NASA. We chose these three because their videos were the easiest to understand and gave the most information relevant to this project.

However, you can find more videos and information on the challenge at:
https://www.bradley.edu/sites/challenge



VIDEO:
MARSHA

play video

The MARSHA building is a tall, cylindrical structure that is narrowest at the top and slightly narrower at the bottom. The exterior looks ribbed from the 3D printing process. A cutaway of the building shows four floors. The 3D printer shown that would build the MARSHA habitat is a tall vertical pole with a horizontal pole attached to it. On the end of the horizontal arm is the printer itself.

Click on the play button above or the url below to open a web browser and play video:
https://www.youtube.com/watch?v=XnrVV0w2jrE

Internet access required to view video

VIDEO:
ZOPHERUS

play video

The ZOPHERUS building is hexagonal in shape at the base, and has two floors. The first floor has walls that are straight up. The top floor is a dome shape. Several buildings of this type are shown next to each other, connected by a very short tunnel.

Click on the play button above or the url below to open a web browser and play video:
https://www.youtube.com/watch?v=lTNqPhrCpdM

Internet access required to view video

VIDEO:

NORTHWESTERN

play video

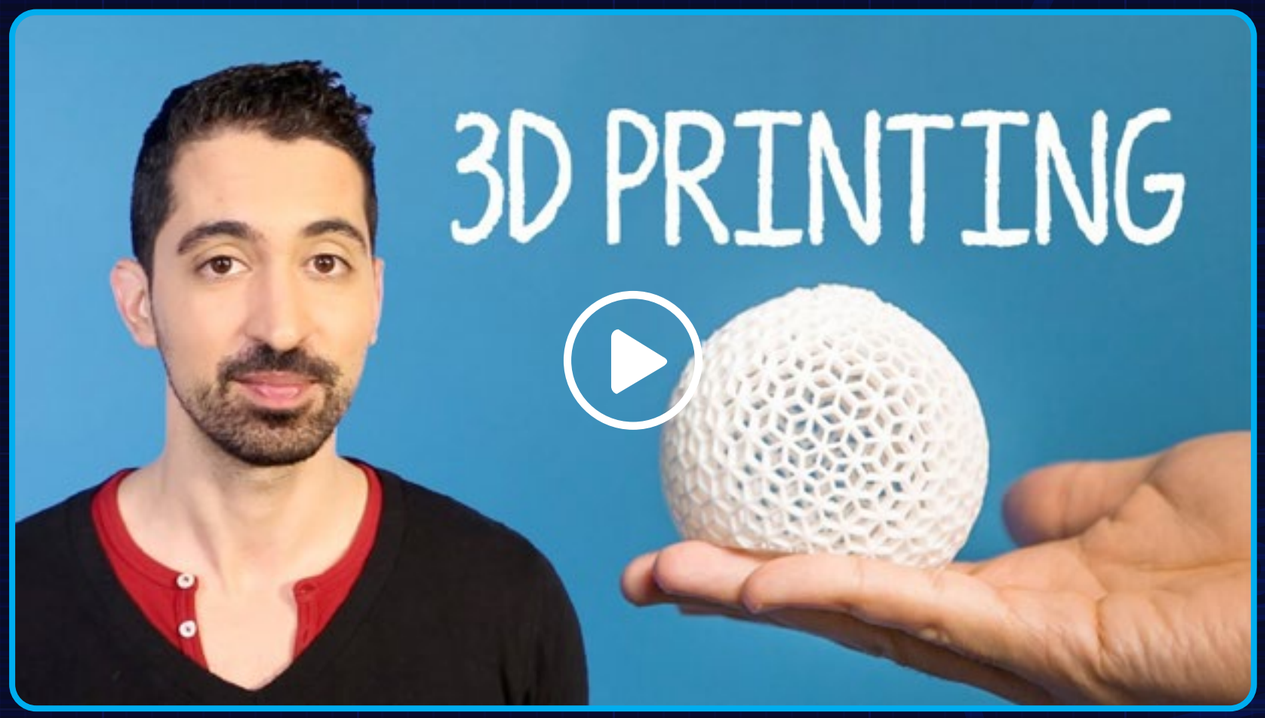
The NORTHWESTERN building is a dome shape with a ribbed structure from the 3D printing process. It is a single floor. The interior has rooms around the perimeter, with a central living area in the center of the dome.

Click on the play button above or the url below to open a web browser and play video:
https://vimeo.com/270669777

Internet access required to view video

VIDEO:

WHAT IS 3D PRINTING AND HOW DOES IT WORK?



play video

For students unfamiliar with 3D printing, there is also an optional video you can show them that explains the basics.

Click on the play button above or the url below to open a web browser and play video:
https://www.youtube.com/watch?v=Vx0Z6LplaMU

Internet access required to view video

ACTIVITY 2:

EVALUATE THE HABITATS

TIME REQUIRED: **5-10 MINUTES**

Have students record the pros and cons of the designs they view. This can be done asynchronously, while viewing of the videos is in progress, or after watching the videos. Students should record answers to three questions about each habitat, using the provided sheet or another means. They are:

- **The Shape**: How easy was it to build to that shape using 3D printers?
- **The Space Inside**: How did you like the inside space? What is spacious or cramped? Could you be comfortable in that space?
- **Materials**: What materials did they use?

At the end students, ask students to pick their favorite and also think about how they might combine what they liked from all three designs and their own ideas to make their own building. In this week's urban planning lesson they will have a chance to put this into action!

VOCABULARY

3D printer: A machine adds materials layer by layer in order to create a 3-dimensional object. You can use this to make small objects up to full buildings. Here is a short video that explains how it works with a smaller at-home version: https://www.youtube.com/watch?v=Vx0Z6LplaMU

Basalt: A volcanic rock that is formed through the rapid cooling of lava

Climate control: Being able to adjust the temperature within a building or room

Concrete: A heavy, rough building material made from a mixture of broken stone or gravel, sand, cement, and water. It can be spread or poured into molds, and forms a mass resembling stone on hardening.

Dry lab: A laboratory space where mostly computer-based simulations happen

Flange: A collar or rib on an object, serving to help secure a pole or similar object into the ground

HDPE: High Density Poly Ethylene (HDPE) is a plastic made from petroleum. It is used in making everything from milk jugs to pipes.

Hydroponic garden: A garden that only uses water and added nutrients to grow plants. Iit does not require soil.

Hi-SEAS: An experiment in which people lived in a simulated Martian habitat, away from everyone else, for many months to learn how best to support astronauts when they eventually go to Mars.

Indigenous: Originating or occurring naturally in a particular place; native. In this case, materials that can be found on Mars.

Lot and block: A system of describing property that "subdivides" land into "blocks" and then into smaller units called "lots"

Martian aggregate: A mix of sand and crushed rock used to make concrete, specifically found on Mars. Also a type of material that is a mix of different minerals.

Metes and bounds: A system of describing property lines using local markers and land features

PLSS, Public Land Surveying System: A system of describing property using a grid. Also known as the rectangular survey system.

Orthographic Projection: A means of representing three-dimensional objects in two dimensions

Thermal swings: Changes in temperature

Uplift forces: Pressure from other objects or from air that can possibly lift something up

Wet ab: A space for experiments to happen, especially if they might be messy or parts might break

View Printable Sheet

URBAN PLANNING LESSON 2B:

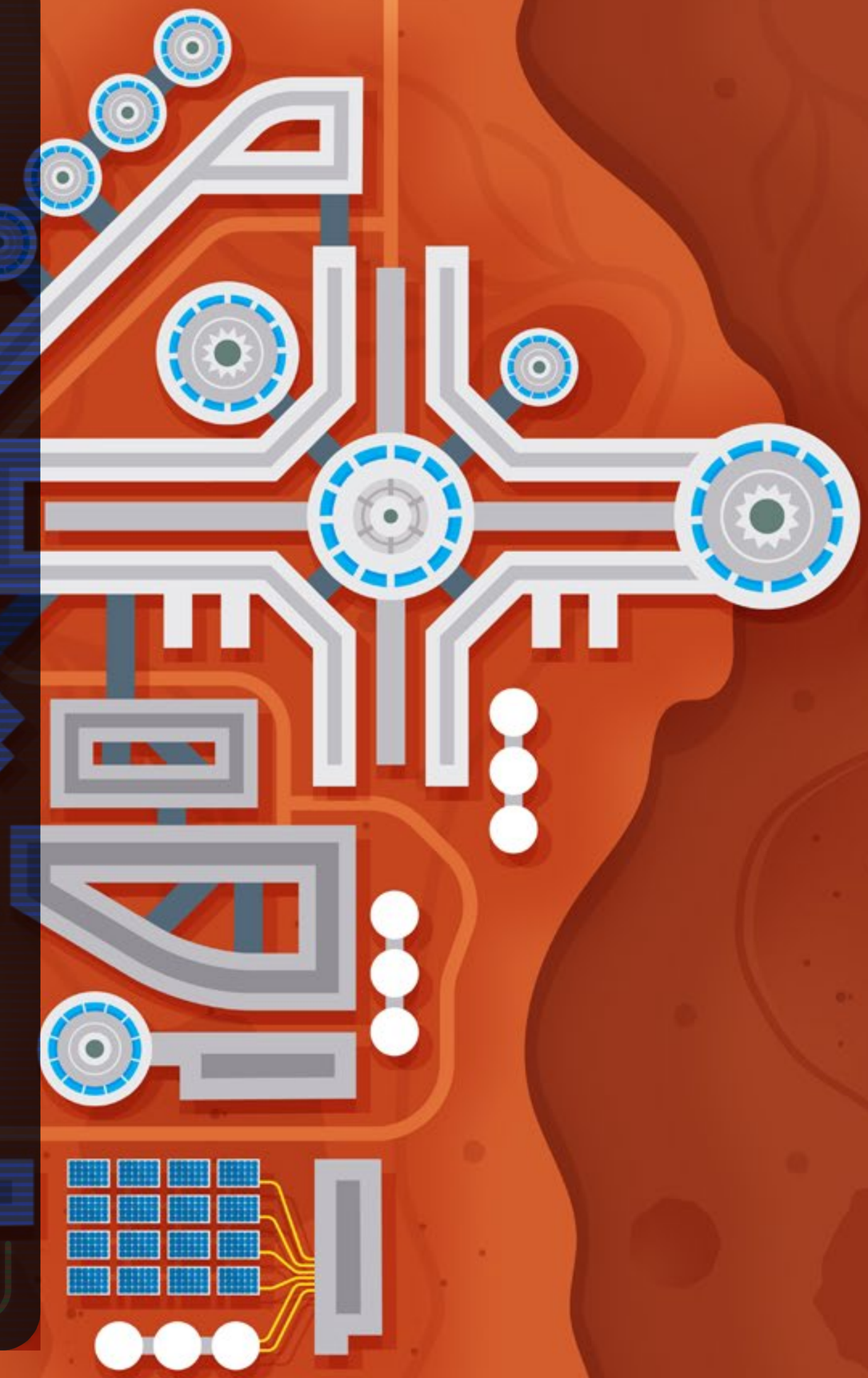
DRAWING FROM DIFFERENT POINTS OF VIEW

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Define “orthographic projection”
- Draw a simple object from three different points of view
- Begin creating a sample drawing of their Mars building



MATERIALS NEEDED

- **Access to “Orthographic Drawing” video**
  https://www.youtube.com/watch?v=SdLegfoMXNA

- **Drawing Example sheet**
  https://drive.google.com/file/d/1ri42oBJ5dvG9zOLoYb7D104fOh44f19x/view?usp=sharing

- **Building elevation images**
  https://en.wikipedia.org/wiki/Architectural_drawing

- **Drawing Sheet -** 1 per student, printed (has 2 sides)
  https://drive.google.com/file/d/1hqTmWIFRzTkZFftlbG32egCvgFPkDaF1/view?usp=sharing

- **Blank or graph paper and drawing tools, computer drawing software, OR other equivalent**
  https://drive.google.com/file/d/1n0bTr68Q-koI_xQSBI-u_pOTKlHedMEM/view?usp=sharing
  (print free graph paper at **https://www.printfreegraphpaper.com**)

- **Small object from home or classroom**

ACTIVITY 1:

DRAW FROM DIFFERENT POINTS OF VIEW

TIME REQUIRED: **15 MINUTES**

Give each student a printed “Drawing Sheet” or the digital equivalent.

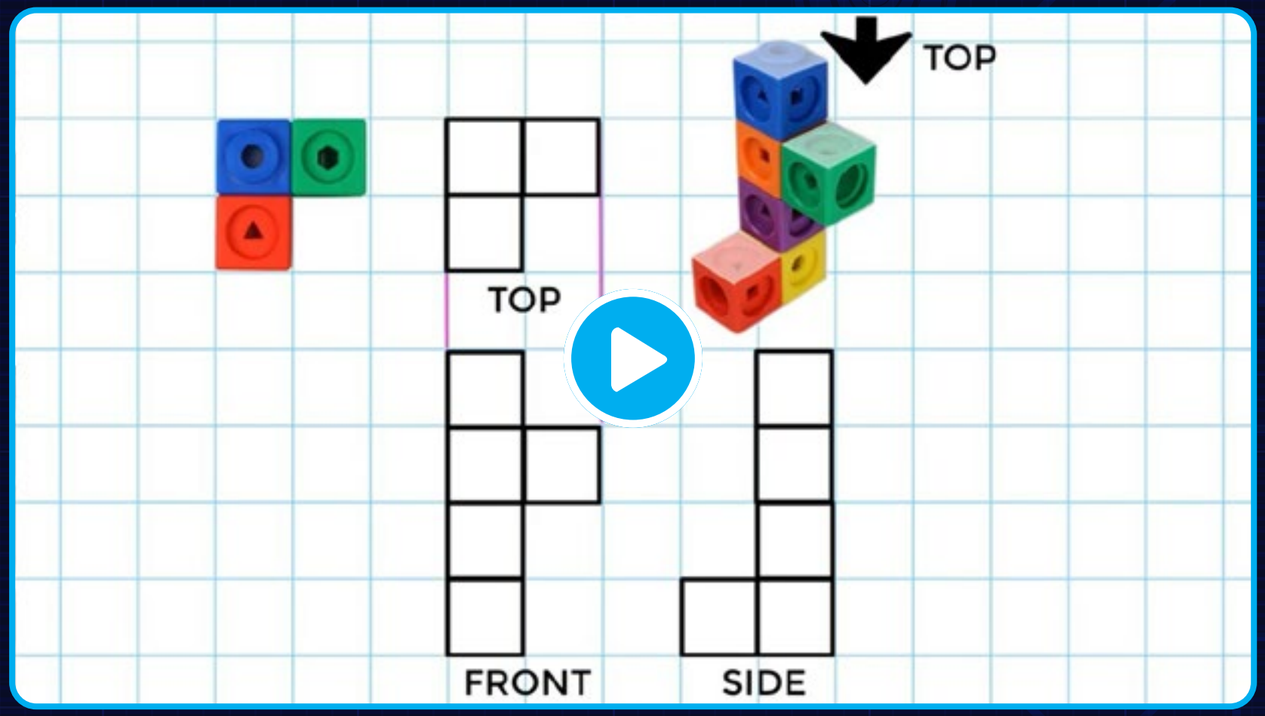
Show them the “Drawing Example” image and talk about orthographic projection and perspective, which is drawing in 3D. *[Watch]* Show students the “Orthographic Drawing” video (2 minutes). On the blank part of their sheet, have them draw the object in the “Drawing Example.”

On the back of the “Drawing Sheet” (with the columns), have students draw the object they chose from home or classroom: front view, side view, and top view. Have them experiment with adding colors, textures, etc. to the drawings. Tell them to try to be as detailed as possible, using colors, texture, blending in, reflections, etc.

Show the students the sample building elevation images from the Wikipedia website. Ask why they think drawings of building plans might be needed from 3 points of view.

VIDEO:

ORTHOGRAPHIC DRAWING



play video

Learn how to make an orthographic (three-view) drawing with simple instructions. From the Intro to Engineering & Design curriculum by Paxton/Patterson College & Career Ready Labs.

Click on the play button above or the url below to open a web browser and play video:
https://www.youtube.com/watch?v=SdLegfoMXNA

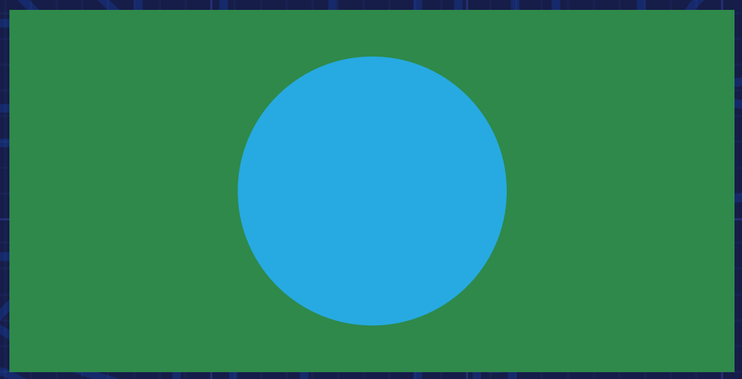
Internet access required to view video

DRAWING EXAMPLE

OBJECT

SIDE VIEW

FRONT VIEW



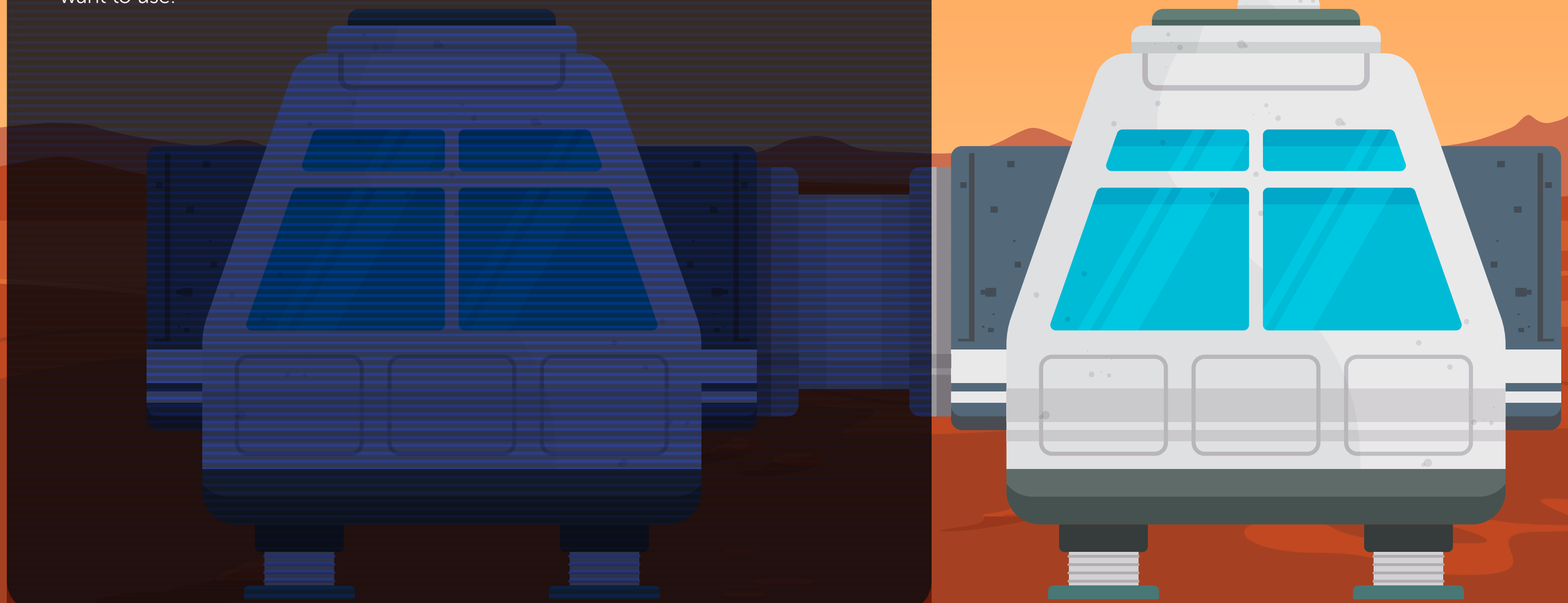
TOP VIEW

ACTIVITY 2:

TALK ABOUT MARS BUILDING DRAWING

TIME REQUIRED: **5 MINUTES**

Have students talk about how they would create a sketch of a building they would like to have in their Mars community. How would they draw from three points of view? What challenges do they need to think about? What colors, textures, etc. might they want to use?



HOMEWORK:

BEGIN TO SKETCH A MARS BUILDING

Students should work on their Mars building sketches. They should try to draw from different points of view. Using graph paper may be helpful.

MARS LESSON 3A:

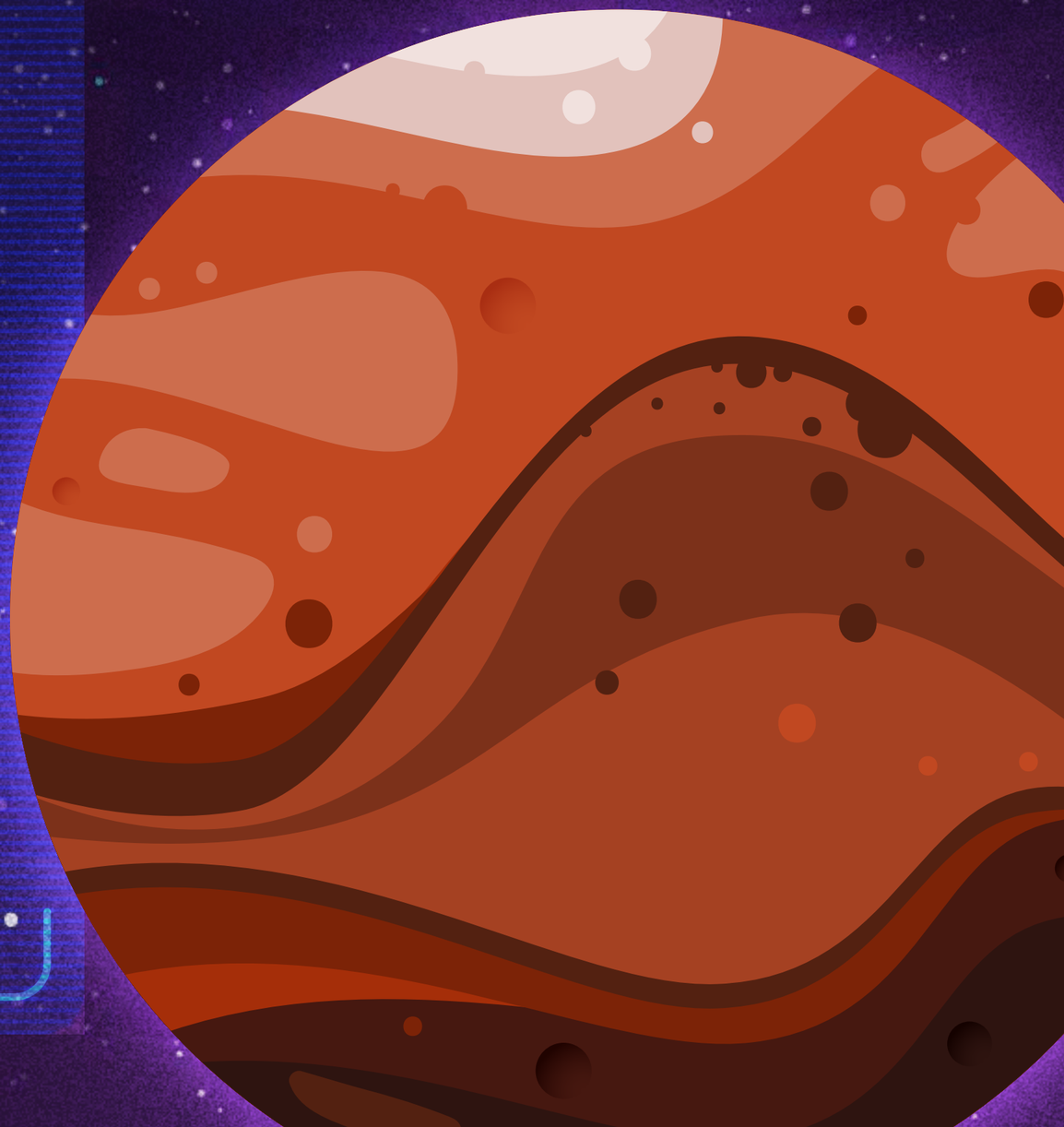
MARTIAN SITE INTRODUCTION

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Compare data about five different sites on Mars
- Consider the pros and cons of building a suitable community for humans at five different sites on Mars



MATERIALS NEEDED

- **Information cards for each site**
  https://drive.google.com/file/d/1bcNCsYCvxnVxi4oqOgdgb7afqMCDoxfj/view?usp=sharing

- **Additional Images of the landing sites from Mars Missions**

- **Building Site Ranking Activity sheet**
  https://drive.google.com/file/d/16yevJ-QsD9Ra7UevUQ6F7F6-CcBxLyZ4/view?usp=sharing

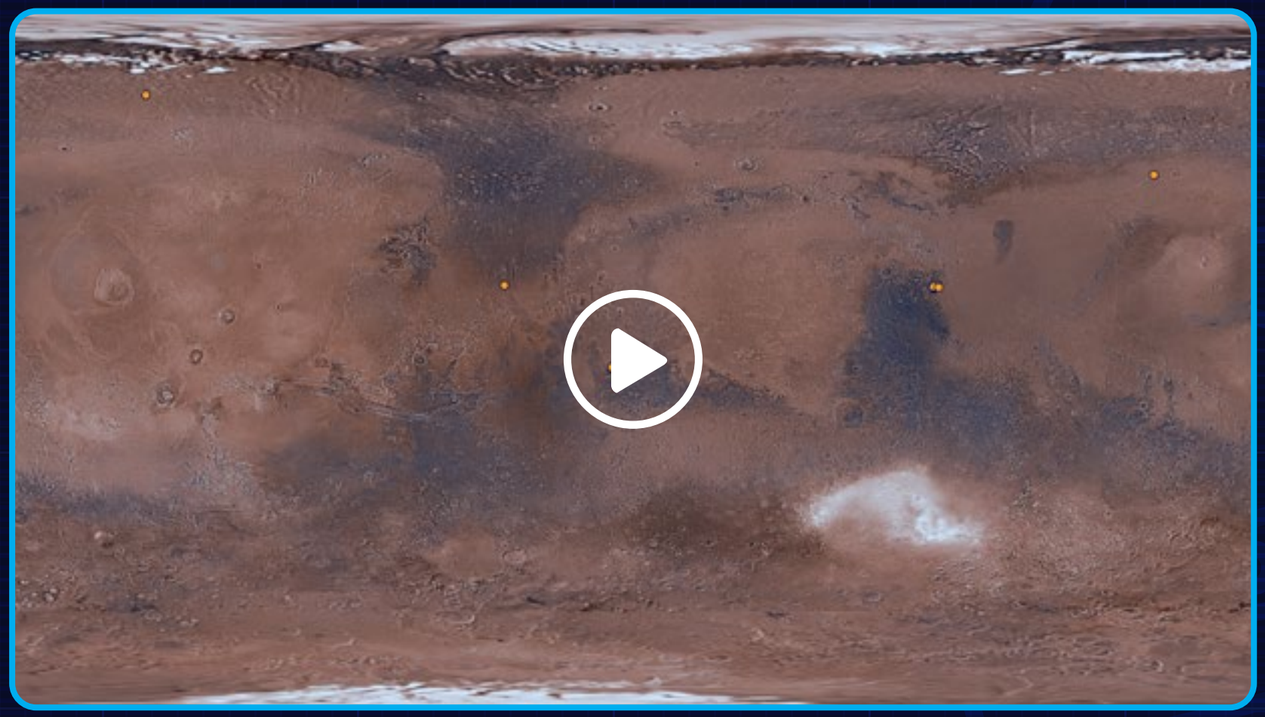
- **Martian Maps**
  - Dust Index (how much dust accumulates in these regions)
  - Water Ice (buried water ice)
  - Water mass fraction (water embedded in the soil, not as easily extracted as ice)
  - Thermal Inertia (how much heat is retained and reemitted at night)

- **Access to video of how to read the maps and information cards**
  https://mediaspace.msu.edu/media/Introduction%20to%20Site%2C%20Maps%2C%20and%20Information%20Cards/1_e86wjti6

- **Optional:** Mars Trek

VIDEO:

INTRODUCTION TO SITE, MAPS, AND INFORMATION CARDS



play video

A short introductory video is provided on how to read each map and information card provided, and how to view each potential site in 3D. You can either use this information for your own teaching or show it directly to the students.

Click on the play button above or the url below to open a web browser and play video:
https://mediaspace.msu.edu/media/Introduction%20to%20Site%2C%20Maps%2C%20and%20Information%20Cards/1_e86wjti6

Internet access required to view video

ACTIVITY:

RANK THE POTENTIAL BUILDING SITES

TIME REQUIRED: **20 MINUTES**

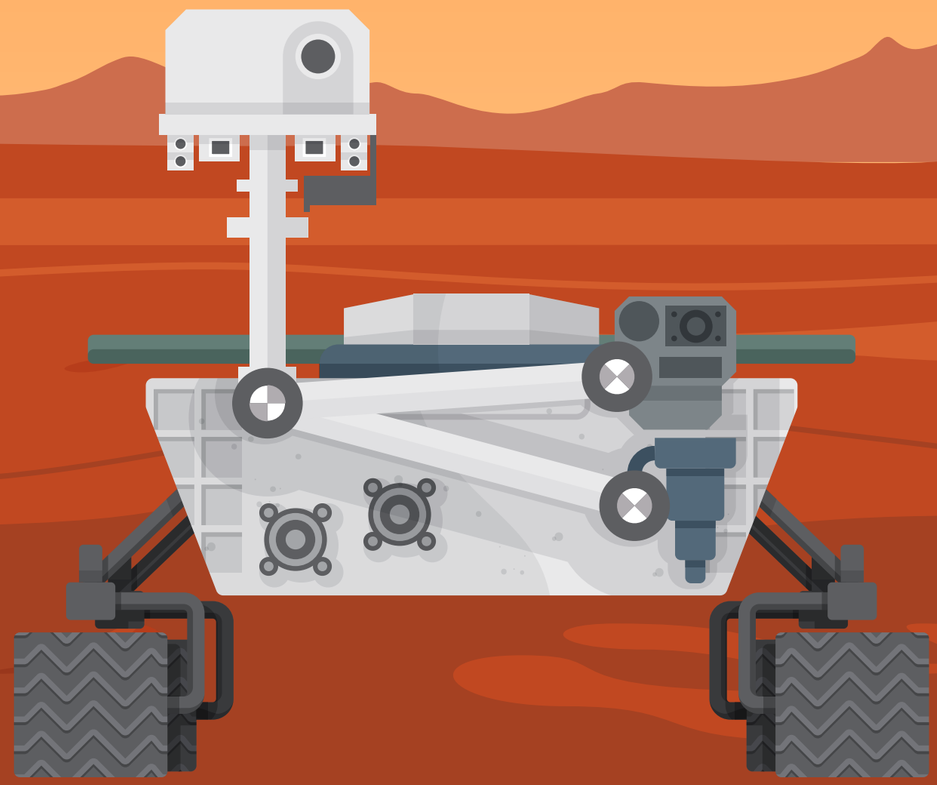
Have students use the Building Site Ranking sheet or some other means of recording information to explore how each site rates in terms of habitat and resources. Have the students use the information cards, each of which includes up close images with a scale marker of about 750 feet on its longest edge. There are also maps on buried ice, relative amount of water, the dust index, and thermal inertia for them to look at. On each characteristic, have them rank how good that site is. This can be done in groups or individually. It can be done asynchronously if needed.

Have students individually decide on where they think the city should be built and write on the worksheet either individually or in small groups. This will be discussed by the whole class next lesson so please make sure students save the worksheets.

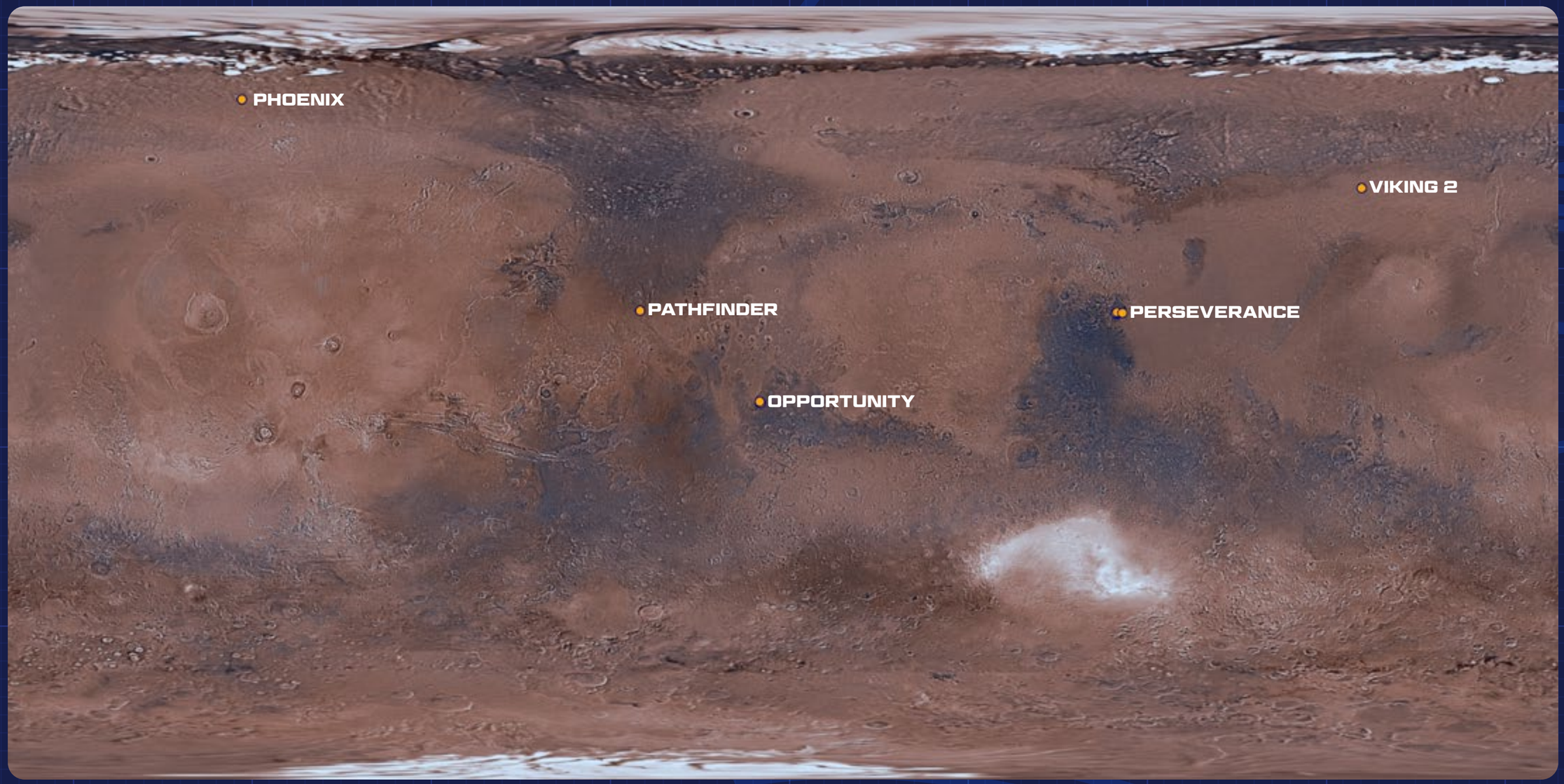
Optional: Send students to Mars Trek to explore the sites up close on their own. Mars Trek also provides access to a lot of other potential data.

ADDITIONAL RESOURCES

https://www.giss.nasa.gov/research/briefs/1999_allison_x1/
https://www.nasa.gov/mission_pages/phoenix/multimedia/6433-20080513.html
https://www.nasa.gov/feature/jpl/nasas-treasure-map-for-water-ice-on-mars



LANDING SITES INFORMATION



PHOENIX

Temperature: -144° to -4°F (-98° to -20°C)
Hours of Daylight: 0h to 16h31m
Composition: Unknown, probably basaltic

view landing site details

PATHFINDER

Temperature: -89° to 9° F (-67° to -13°C)
Hours of Daylight: 10h54m to 13h23m
Composition: Probably volcanic basalt

view landing site details

OPPORTUNITY

Temperature: -101° to 43°F (-73° to 6°C)
Hours of Daylight: 11h51m to 12h06m
Composition: Sulfur-rich sedimentary rock, basaltic sand

view landing site details

PERSEVERANCE

Temperature: -115° to 44° F (-83° to 7°C)
Hours of Daylight: 10h56m to 13h20m
Composition: Clay, Carbonates, Volcanic rocks

view landing site details

VIKING 2

Temperature: -184° to 57°F (-120° to 14°C)
Hours of Daylight: 8h10m to 16h02m
Composition: Unknown, probably basaltic

view landing site details

PHOENIX
LANDING SITE

TEMPERATURE: -144° TO -4°F (-98° TO -20°C)
HOURS OF DAYLIGHT: 0H TO 16H31M
COMPOSITION: UNKNOWN, PROBABLY BASALTIC

Aerial View of Phoenix Landing Site: Image shows an aerial view of the Phoenix landing site about 2.5 kilometers by 3 kilometers. The ground appears featureless.

An illustration of Spartan Stadium (that is approximately 750x500 feet) is included next to the landing site for size reference. It is approximately 12 percent of the width and 16 percent of the height of the image.

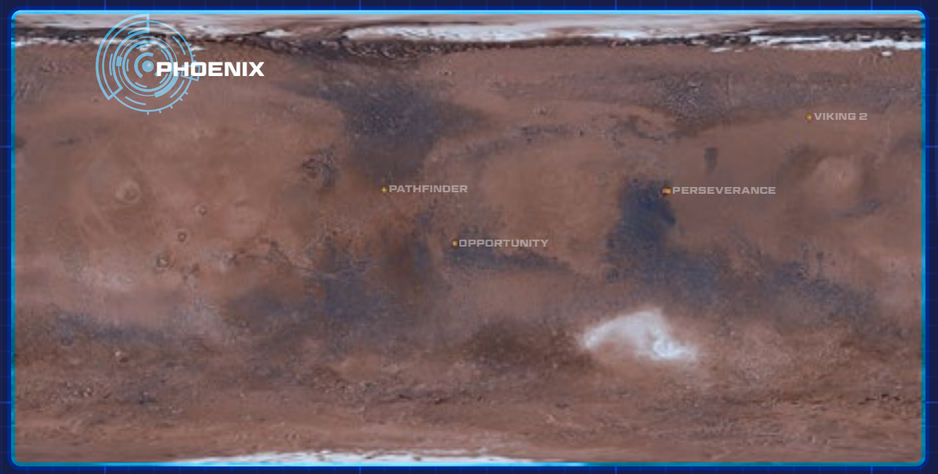


PHOTO: **PHOENIX LANDING SITE**

Shows a very flat, dusty landscape, A few pebbles and 6-inch sized rocks are seen sporadically. The foreground shows the solar panels and main body of a Mars robot.

PATHFINDER
LANDING SITE

TEMPERATURE: -89° TO 9° F (-67° TO -13°C)
HOURS OF DAYLIGHT: 10H54M TO 13H23M
COMPOSITION: PROBABLY VOLCANIC BASALT

Aerial View of the Pathfinder Landing Site: Image shows an aerial view of the Pathfinder landing site about 4 kilometers by 6 kilometers. mostly featureless except for a small crater and small hill near the top of the image and a larger crater near the bottom.

An illustration of Spartan Stadium (that is approximately 750x500 feet) is included next to the landing site for size reference. It is approximately the size of the small hill an crater and about a fifth the size of the larger crater.

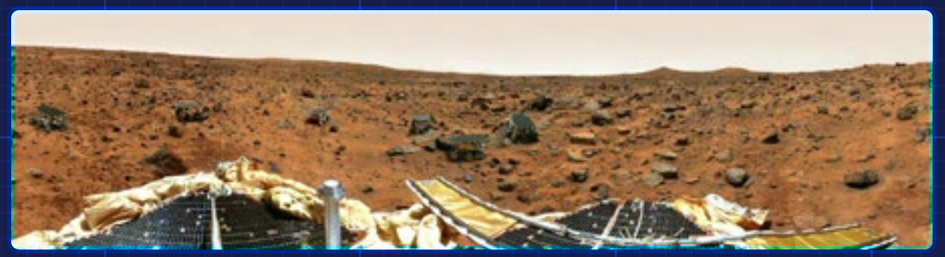
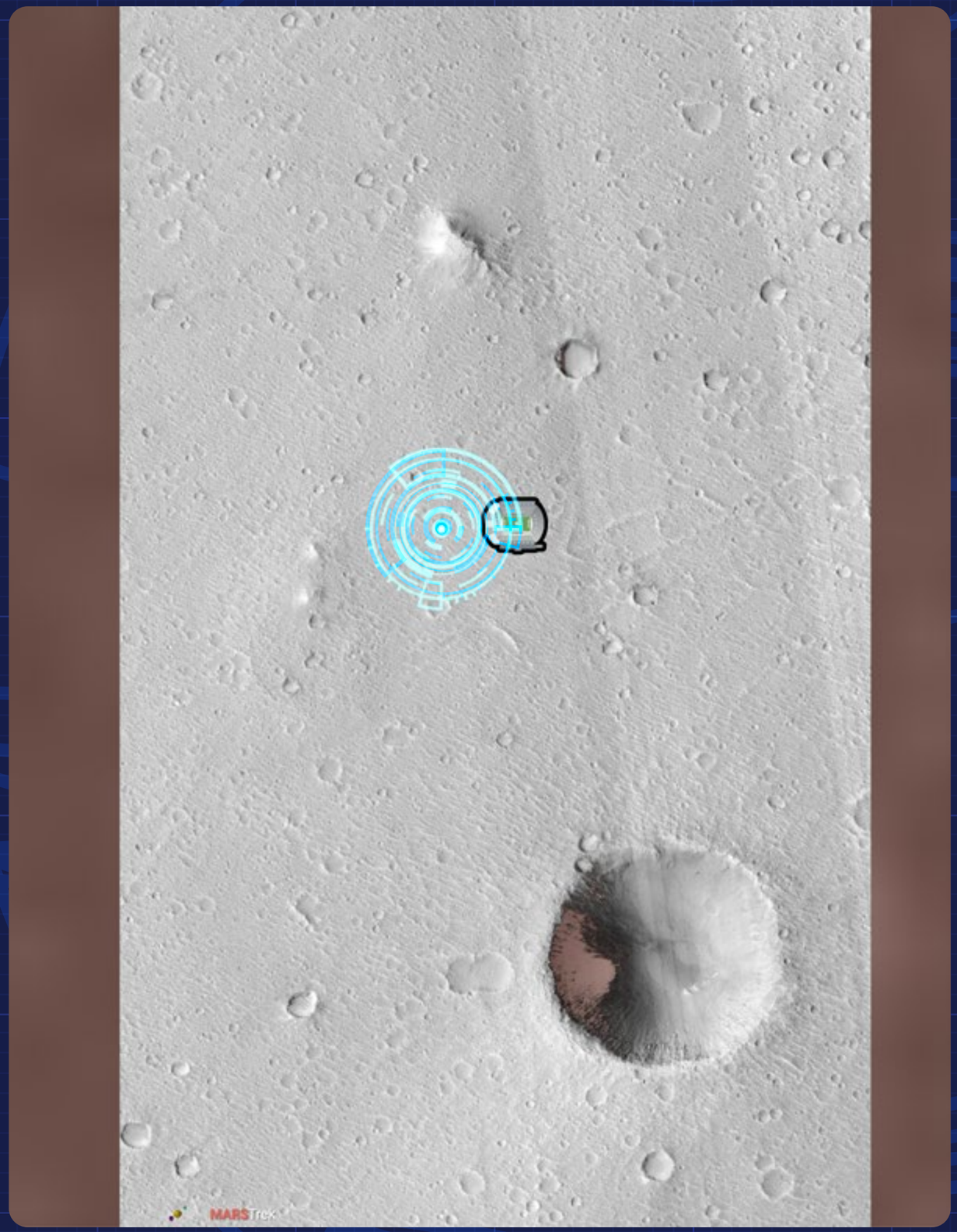


PHOTO: PATHFINDER LANDING SITE

Shows an uneven landscape, orange in color with dark grey rocks about 1 to 2 feet in size. The foreground shows a Mars lander with solar panels and a small microwave-sized rover in front of it.



OPPORTUNITY
LANDING SITE

TEMPERATURE: -101° TO 43°F (-73° TO 6°C)
HOURS OF DAYLIGHT: 11H51M TO 12H06M
COMPOSITION: SULFUR-RICH SEDIMENTARY ROCK, BASALTIC SAND

Aerial View of the Opportunity landing site about 10 kilometers by 15 kilometers. The ground appears mottled. The left hand rim of a crater is shown in the bottom right hand quarter of the image.

An illustration of Spartan Stadium (that is approximately 750x500 feet) is included next to the landing site for size reference. It very small compared the to image.

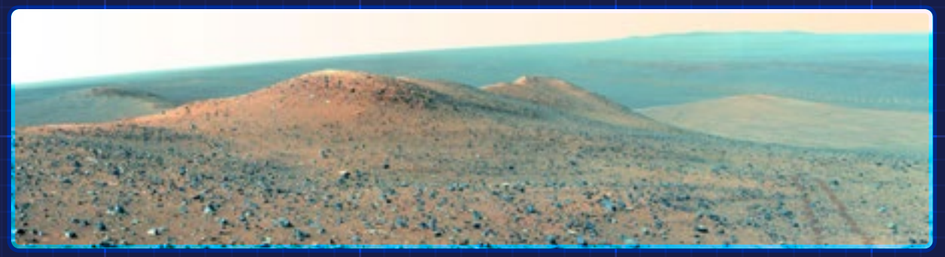


PHOTO: OPPORTUNITY LANDING SITE

Shows a hilly landscape that is orange in color with large, dark, rocks about a foot across in size. Also seen at right are rover tracks in the dusty soil and over rocks.

PERSEVERANCE
LANDING SITE

TEMPERATURE: -115° TO 44° F (-83° TO 7°C)
HOURS OF DAYLIGHT: 10H56M TO 13H20M
COMPOSITION: CLAY, CARBONATES, VOLCANIC ROCKS

Aerial View of the Phoenix landing site about 10 kilometers by 15 kilometers. The ground to be very hilly and rough with what appears to be dry river bed near the top of the image. There is flat land on right of the image.

An illustration of Spartan Stadium (that is approximately 750x500 feet) is included next to the landing site for size reference. It appears small compared to the hilly features.

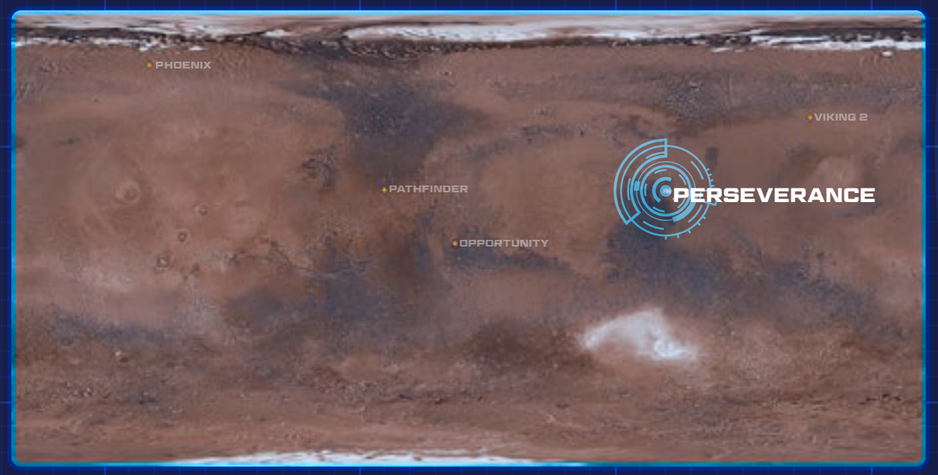
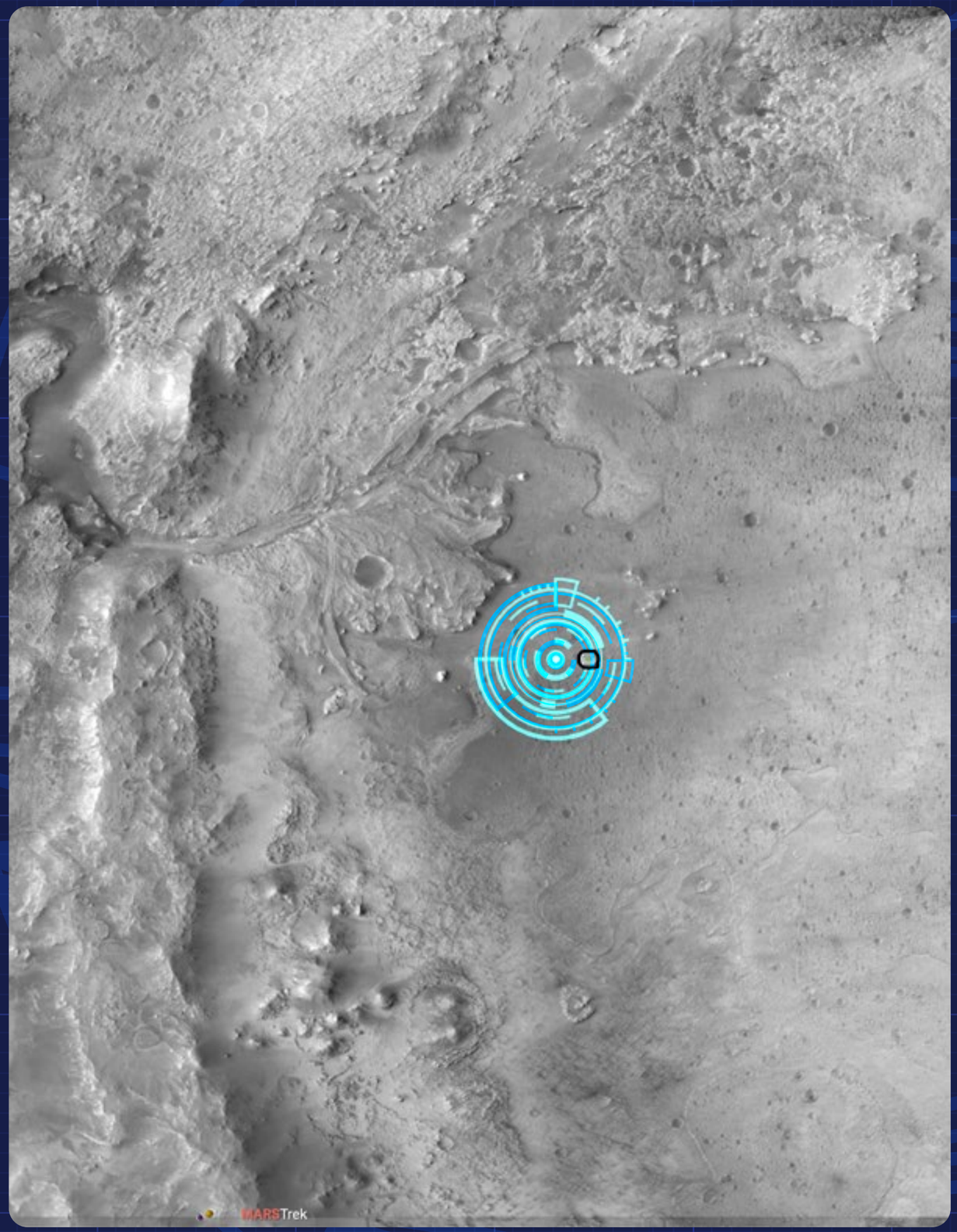


PHOTO: PERSEVERANCE LANDING SITE

Shows the Perseverance rover in the foreground and a Martian landscape that is mostly flat near the rover. Some flat rocks are embedded in the ground. In the distance some hills are present.



VIKING 2
LANDING SITE

TEMPERATURE: -184° TO 57°F (-120° TO 14°C)
HOURS OF DAYLIGHT: 8h10m TO 16h02m
COMPOSITION: CLAY, UNKNOWN, PROBABLY BASALTIC

Aerial View of the Viking 2 landing site about 2.5 kilometers by 3 kilometers. The ground appears mostly featureless with a few 2 kilometer sized craters near the bottom of the image.

An illustration of Spartan Stadium (that is approximately 750x500 feet) is included next to the landing site for size reference. It is approximately a sixth of the width and a eighth of the height of the image.

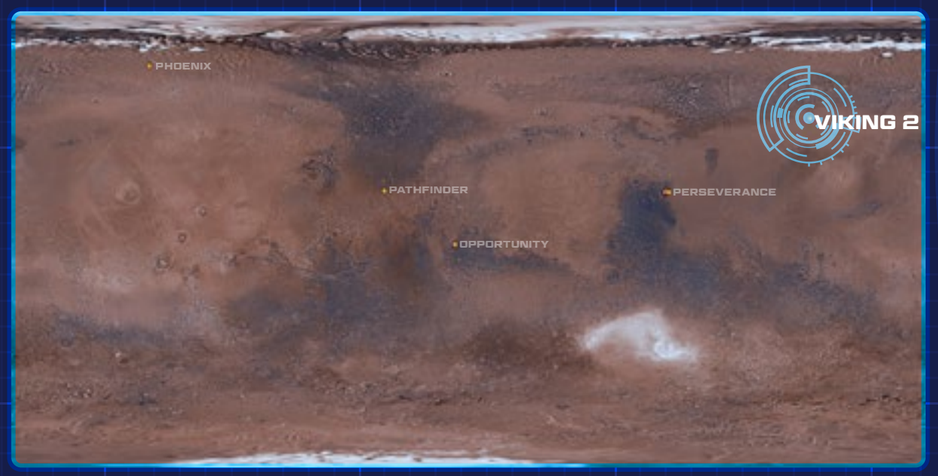
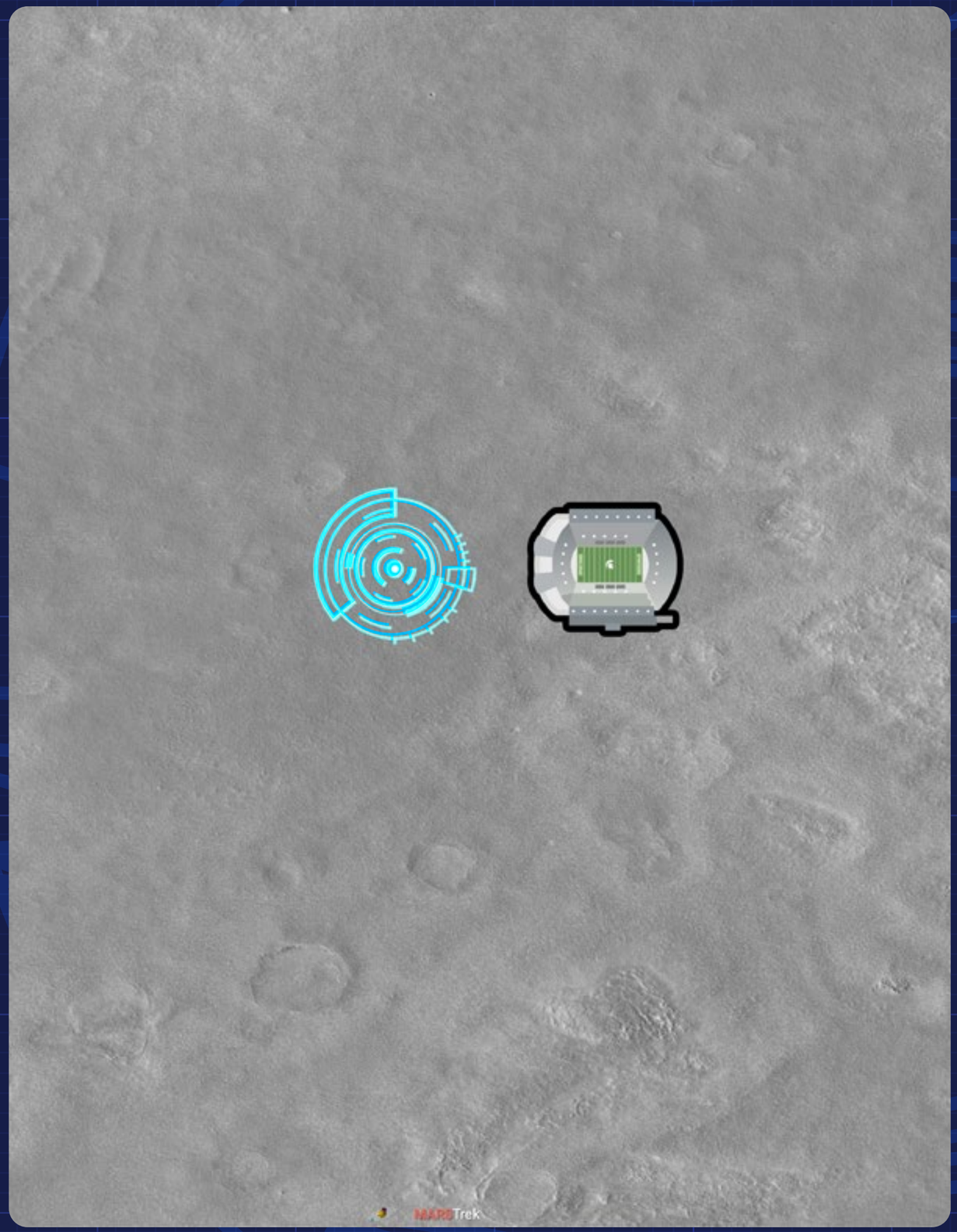


PHOTO: VIKING 2 LANDING SITE

Shows a flat landscape covered heavily in very large, 2- to 3-foot sized light-colored rocks. A robotic arm of the Viking 2 lander is in the foreground.



LANDING SITE IMAGES

Additional Images of the landing sites from Mars Missions

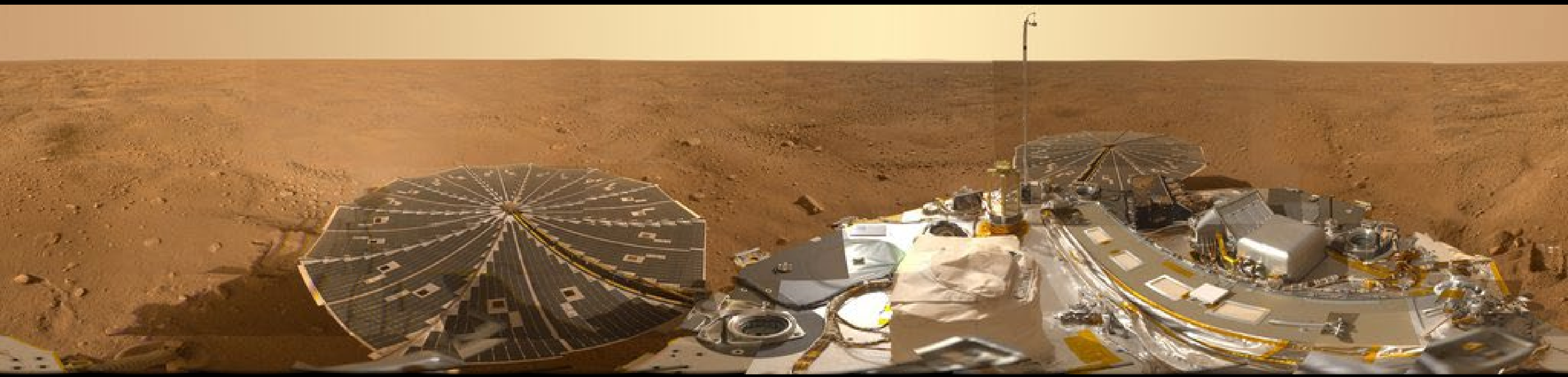


PHOTO:

PHOENIX LANDING SITE

Shows a very flat, dusty landscape, A few pebbles and 6-inch sized rocks are seen sporadically. The foreground shows the solar panels and main body of a Mars robot.

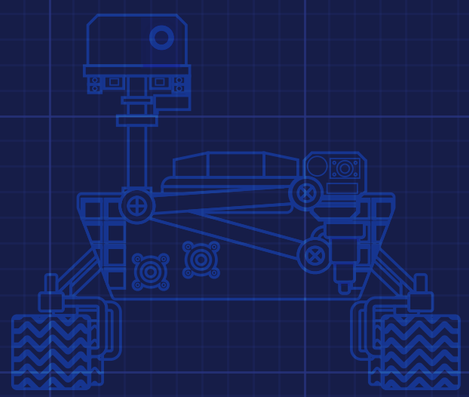


PHOTO:

PATHFINDER LANDING SITE

Shows an uneven landscape, orange in color with dark grey rocks about 1 to 2 feet in size.
The foreground shows a Mars lander with solar panels and a small microwave-sized rover in front of it.

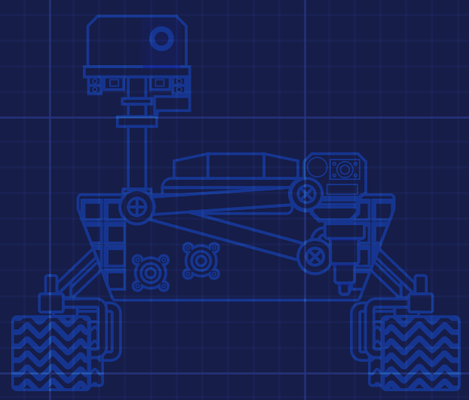


PHOTO:

OPPORTUNITY LANDING SITE

Shows a hilly landscape that is orange in color with large, dark, rocks about a foot across in size.
Also seen at right are rover tracks in the dusty soil and over rocks.

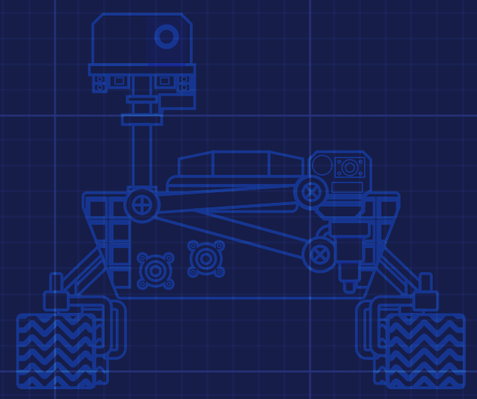
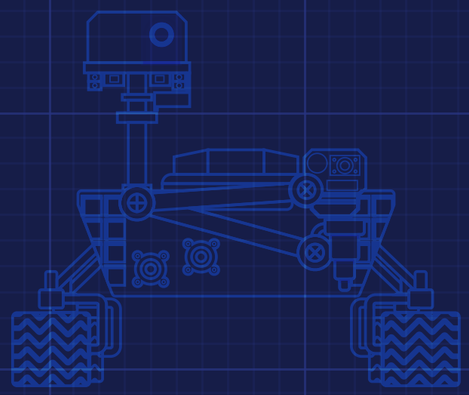


PHOTO:
PERSEVERANCE LANDING SITE

Shows the Perseverance rover in the foreground and a Martian landscape that is mostly flat near the rover. Some flat rocks are embedded in the ground. In the distance some hills are present.



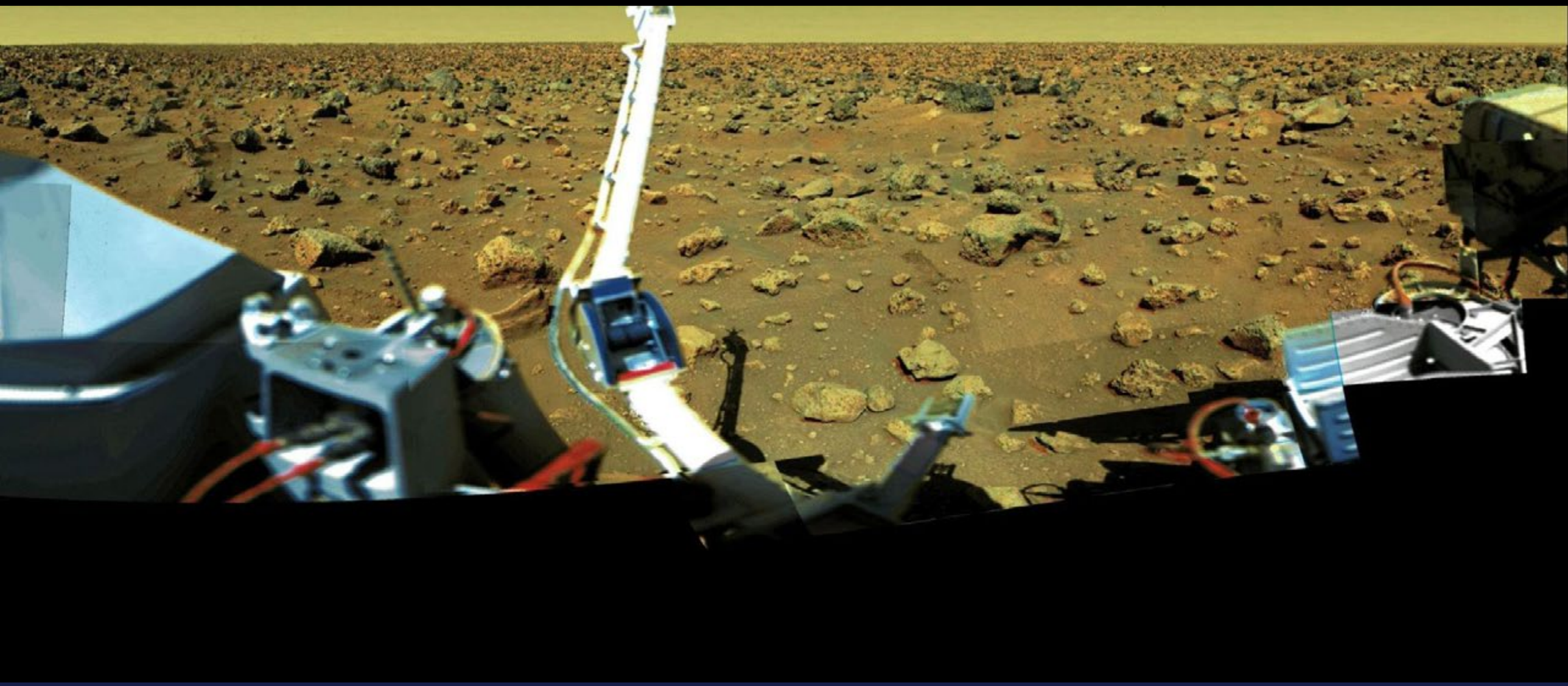
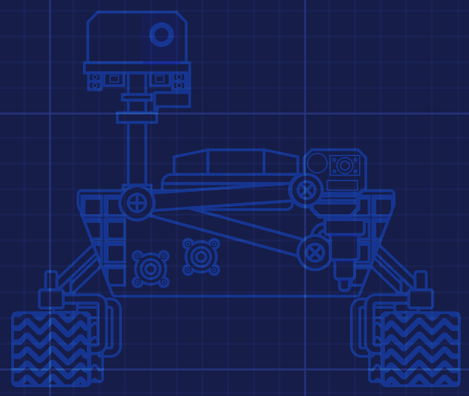


PHOTO:

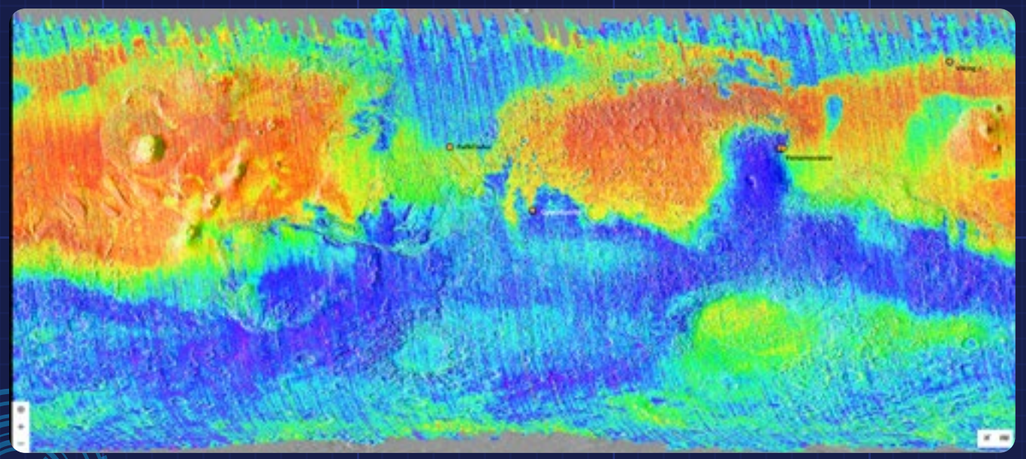
VIKING 2 LANDING SITE

Shows a flat landscape covered heavily in very large, 2- to 3-foot sized light-colored rocks.
A robotic arm of the Viking 2 lander is in the foreground.



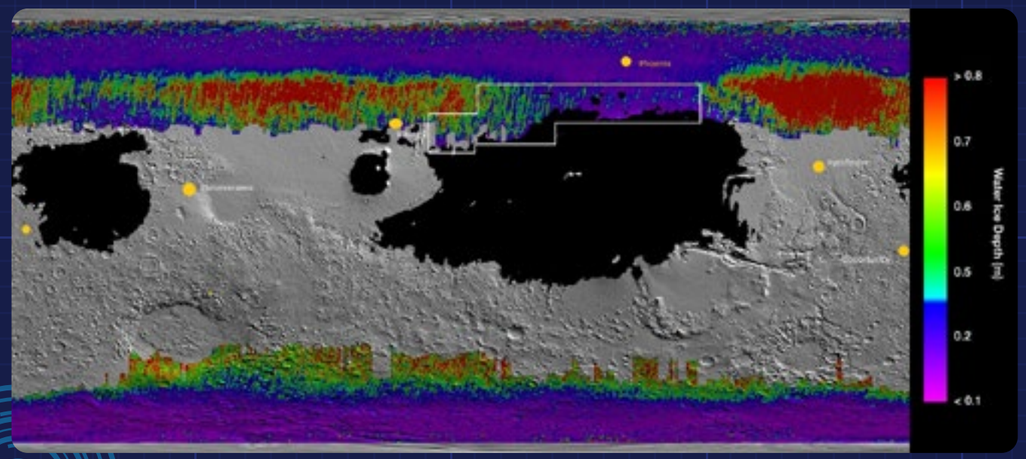
MARS MAPS

Maps on buried ice, relative amount of water, the dust index, and thermal inertia.



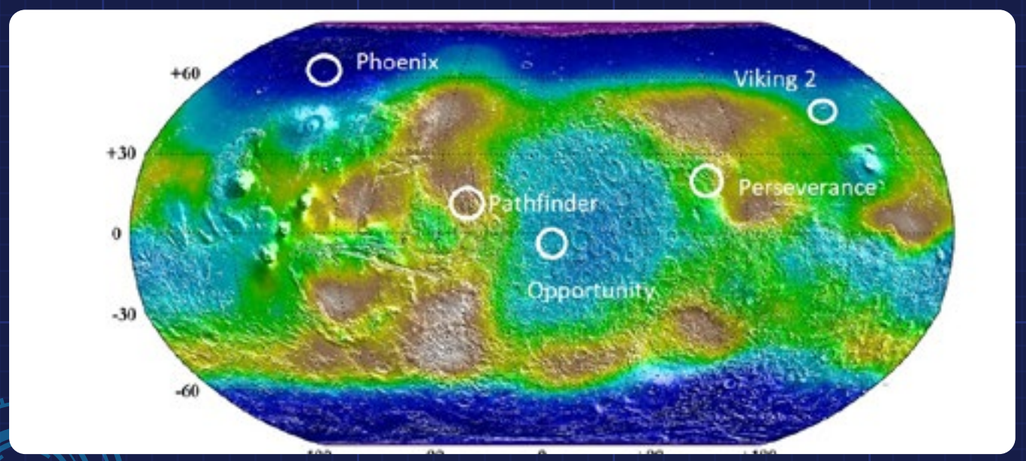
DUST MAP

view larger map



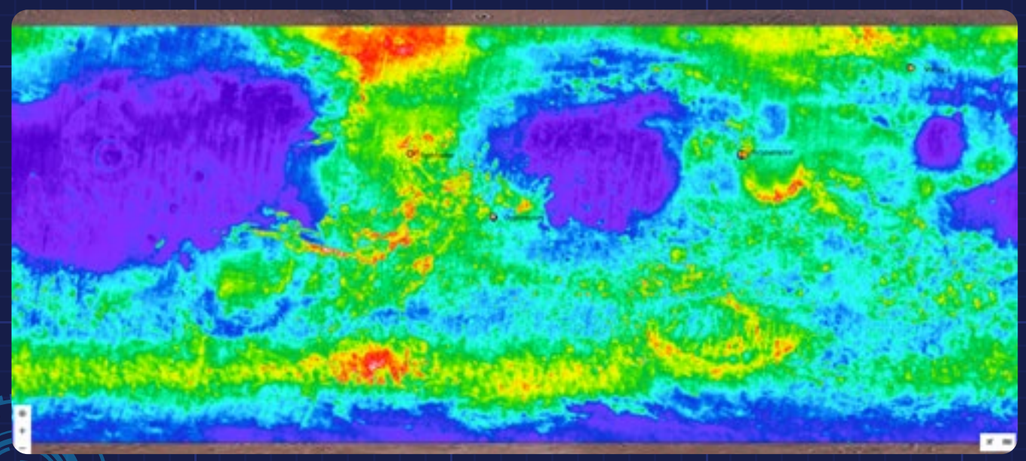
ICE MAP

view larger map



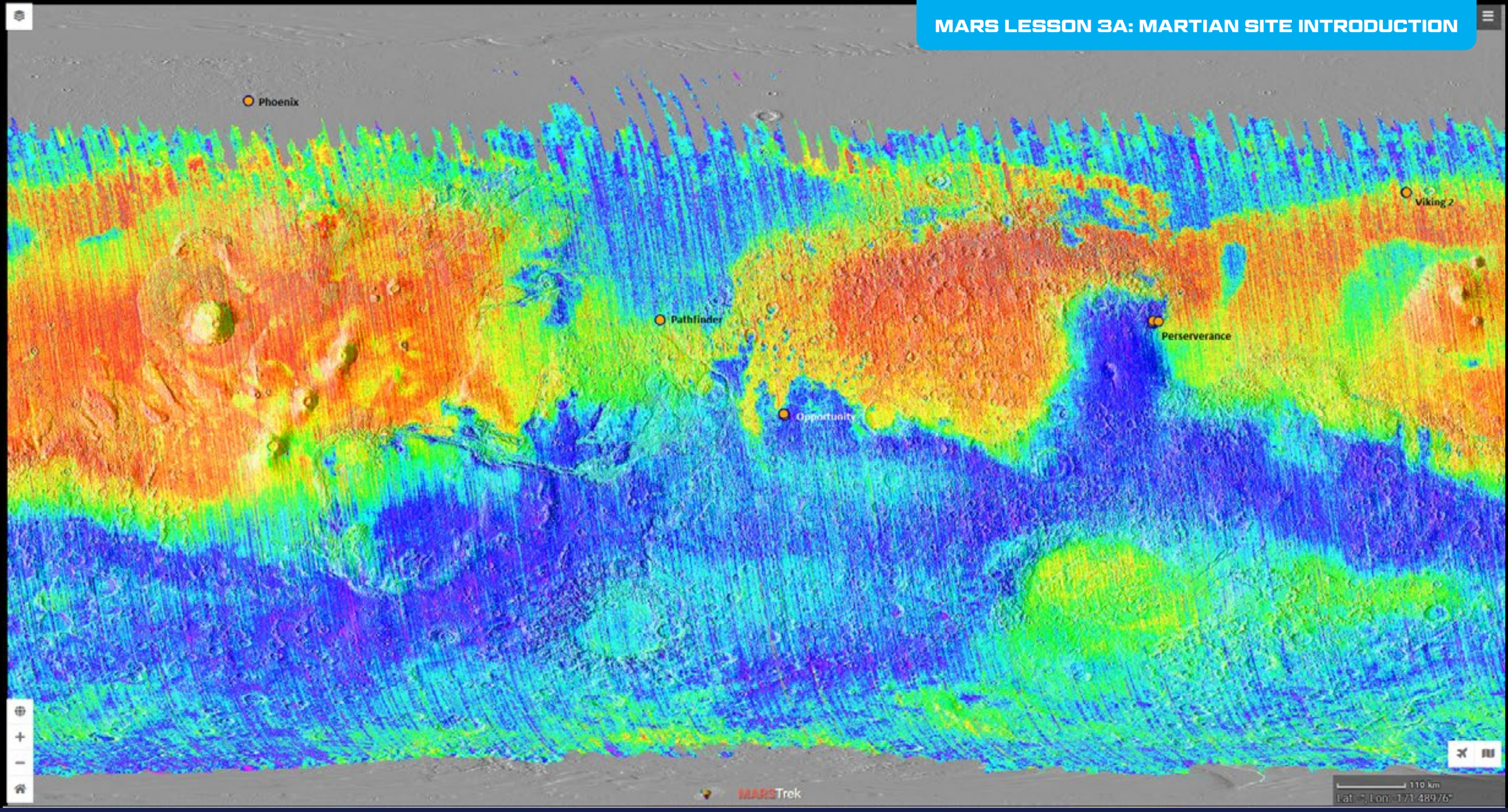
MASS FRACTION OF WATER

view larger map



THERMAL INERTIA

view larger map

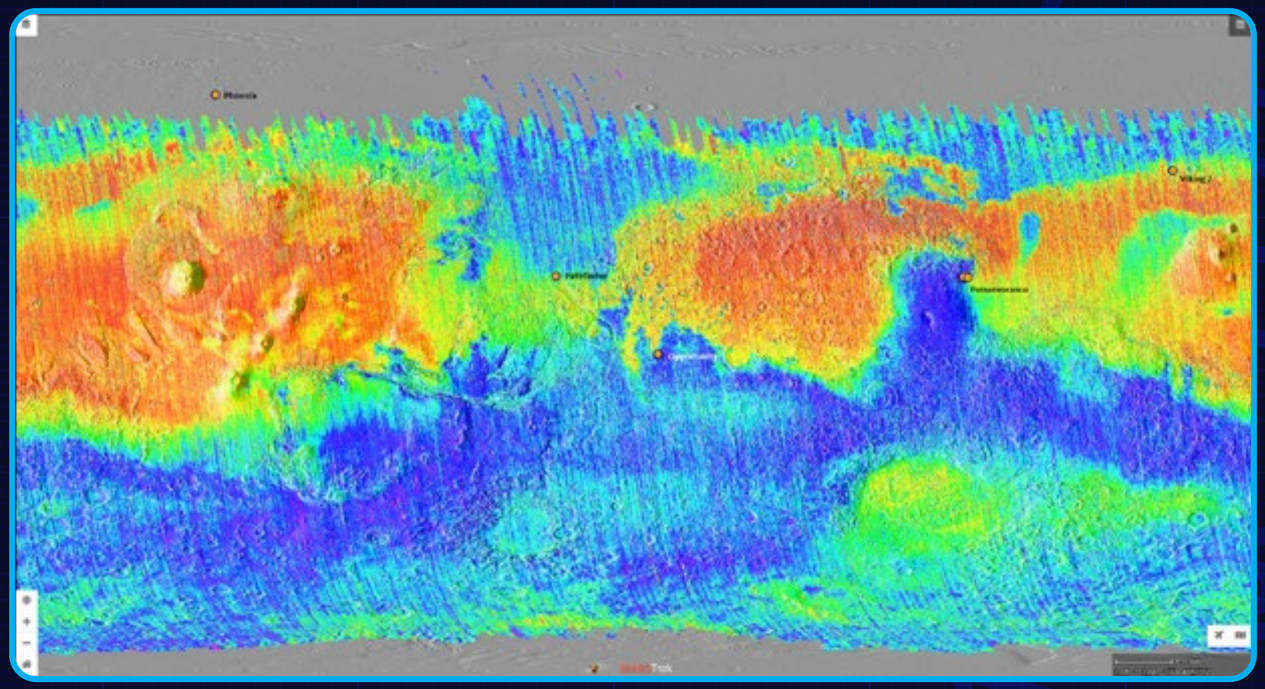


DUST MAP:
DESCRIPTION OF DATA REPRESENTED

This map shows the relative amount of dust obscuring the surface of Mars. This was made using data with the Thermal Emission Spectrometer (TES) on the Mars Global Surveyor spacecraft. This is a flattened version of Mars. If you drew a horizontal line through the middle of the image that would be the equator, while the upper and lower parts of the image are closer to the poles.

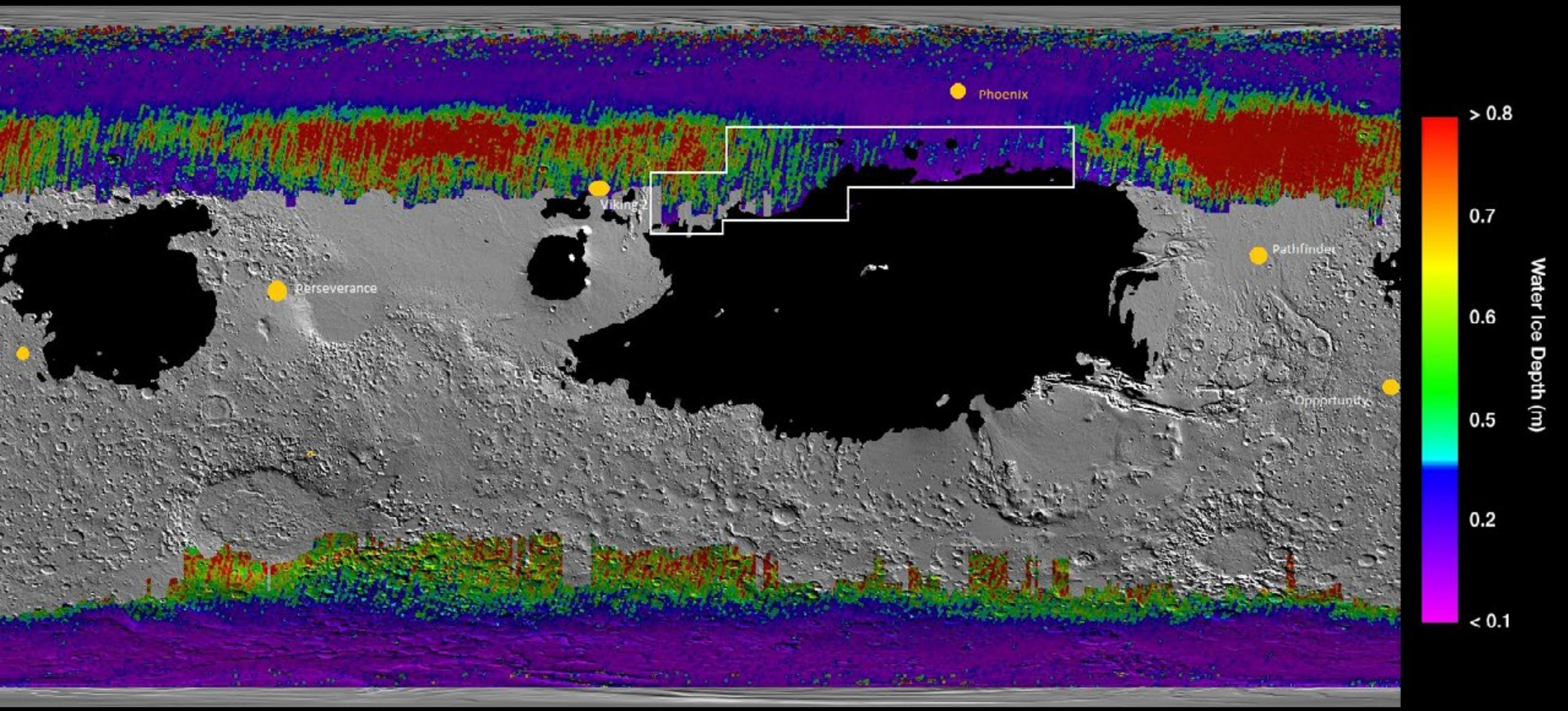
Redder areas are dustiest. In decreasing levels of dustiness are the areas marked in orange, then in yellow, and then in light blue. Dark blue areas are the least dusty.

DUST MAP:
IMAGE DESCRIPTION



This flat image of Mars shows some sporadic craters and mountains. The map is in black and white with a colorful overlay to represent the dust data. The upper and lower third of the image are still in black and while with no data represented. The rest of the image shows three large patches of red areas in an area that is about two thirds of the upper half of the image from the equator. At the bottom below the equator, a large greenish yellow patch is at the right and the remaining area is teal to dark blue.

The sites are marked by orange dots. Phoenix is at the upper left of the image and has no data. Opportunity is on a dark blue area right in the middle of the image, sitting almost on the equator line. Pathfinder is on a green to blue area that is about a third of the way above the equator line and to the left of Opportunity. Perseverance is on a blue area that is about a third of the way above the equator line and to the right of Opportunity. Viking is to the upper right of Perseverance at a latitude about two-thirds of the way up from the equator and on a green to yellow spot.

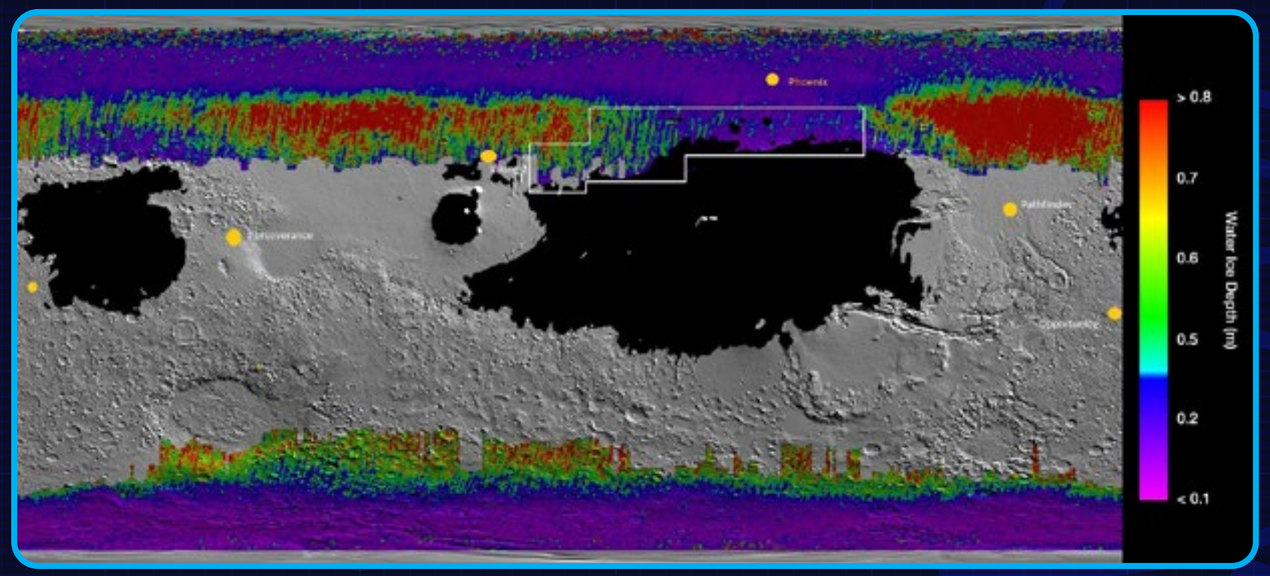


ICE MAP:
DESCRIPTION OF DATA REPRESENTED

There is some water ice on Mars, but a lot of it is under the surface. This map shows the relative depths of water ice beneath the surface. This is a flattened version of Mars. If you drew a horizontal line through the middle of the image that would be the equator, while upper and lower parts of the image are closer to the poles.

In red areas, the ice is deeper (around 2 to 3 feet) whereas in purple/blue areas ice is closer to the surface (only inches). This map is incomplete as this is where we were able to measure the depth. Where there isn't information, it means we can't know and so you can assume it's not as easy to get to!

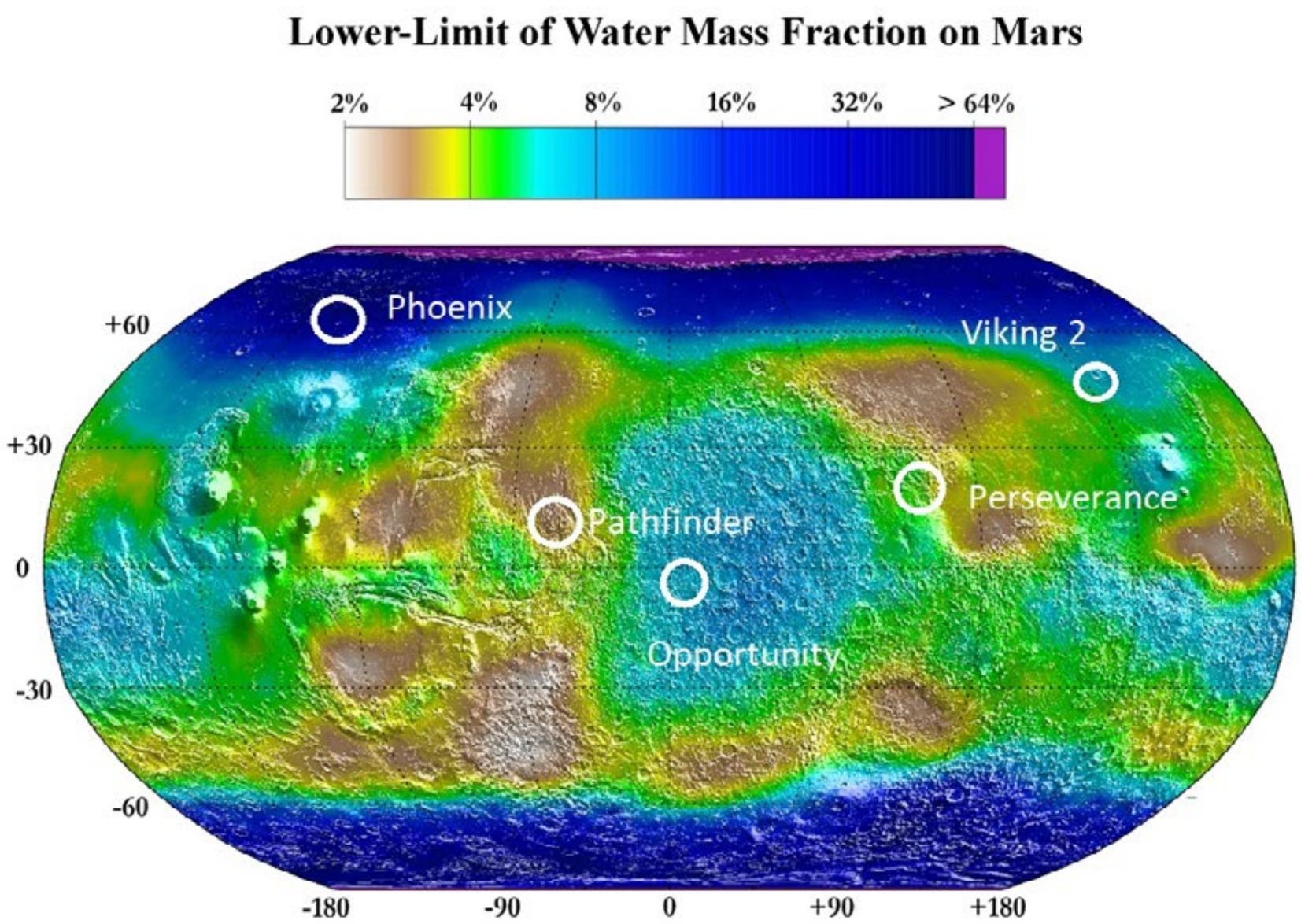
ICE MAP:
IMAGE DESCRIPTION



This flat image of Mars shows some sporadic craters and mountains. The map is in black and white with a colorful overlay to represent the water ice data. The upper and lower third of the image show colorful patches.The upper and lower sixths of the map show bands of dark blueish purple. The next sixth of the map below the upper band of purple shows a big patch of red on the right hand side surrounded by an outline of green. To the immediate left there is a purple path and to the left of that, across the remaining left portion of the image, is a long narrow patch of red with green outlining it. Just above the purple band on the lower part of the image there is a band of green and red spots. The rest of the image is in black and white showing no data but still showing textural features on Mars like craters and mountains.

Three patches of black on the image indicate there is absolutely no information about those areas. There is a big patch in the middle right of the image. A set of three small patches is to the left of that big patch. A medium sized patch appears at the left edge of the image.

Sites are marked by an orange dot. The orientation of this map is slightly different from other maps used. Phoenix is near the top of the image, just right of center, and is on a dark blue area of the map. Opportunity is marked on a colorless area on the right middle edge of the image. Pathfinder is about a third of the way above the equator and to the left of Opportunity, on an area with no color. Perseverance is about a third of the way above the equator line and on the left side of the image, on an area with no color. Viking is to the upper right of Perseverance at a latitude about two-thirds of the way up from the equator and is on a dark blue to green area.



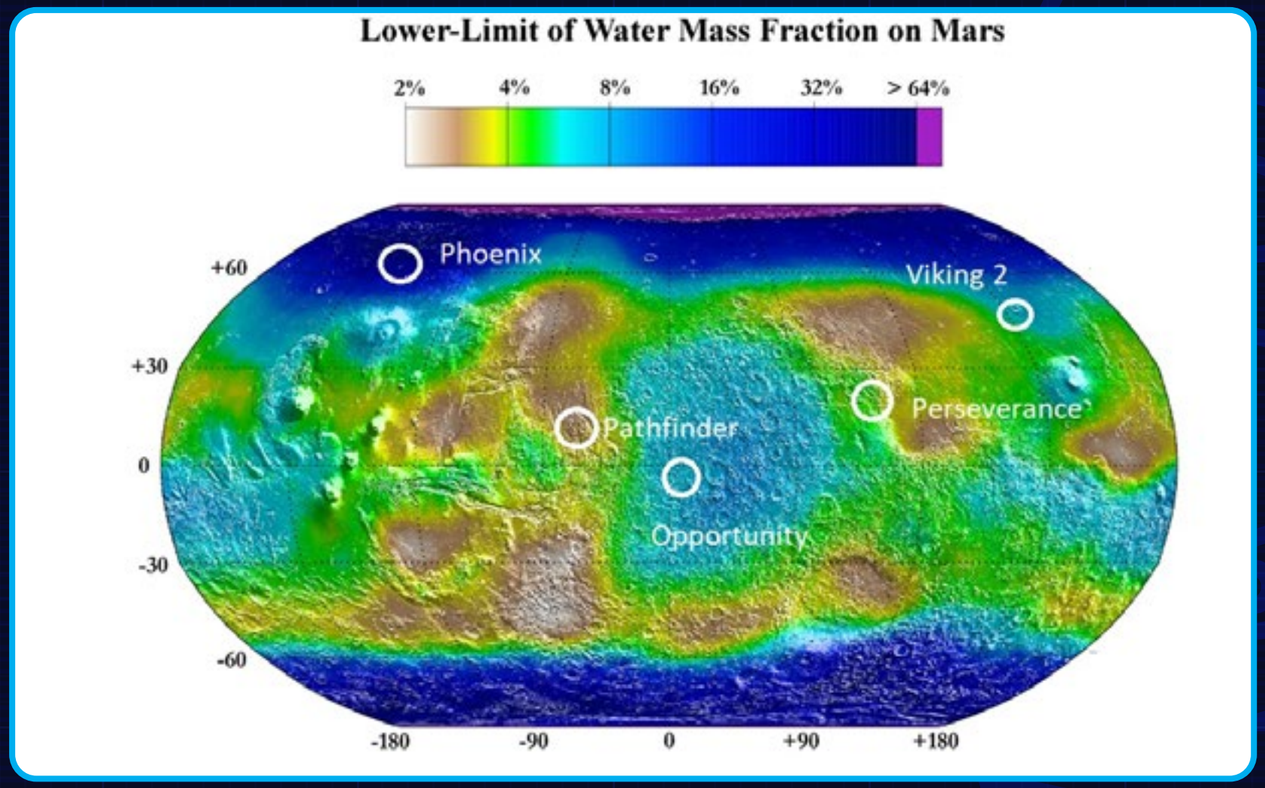
MASS FRACTION OF WATER:

DESCRIPTION OF DATA REPRESENTED

This map shows the relative amount of water within the upper 1 meter, or 3 feet, of the Martian soil. This would be the amount of water that is easily accessible in the Martian soil. This is a flattened version of Mars. If you drew a horizontal line through the middle of the image that would be the equator while upper and lower parts of the image are closer to the poles.

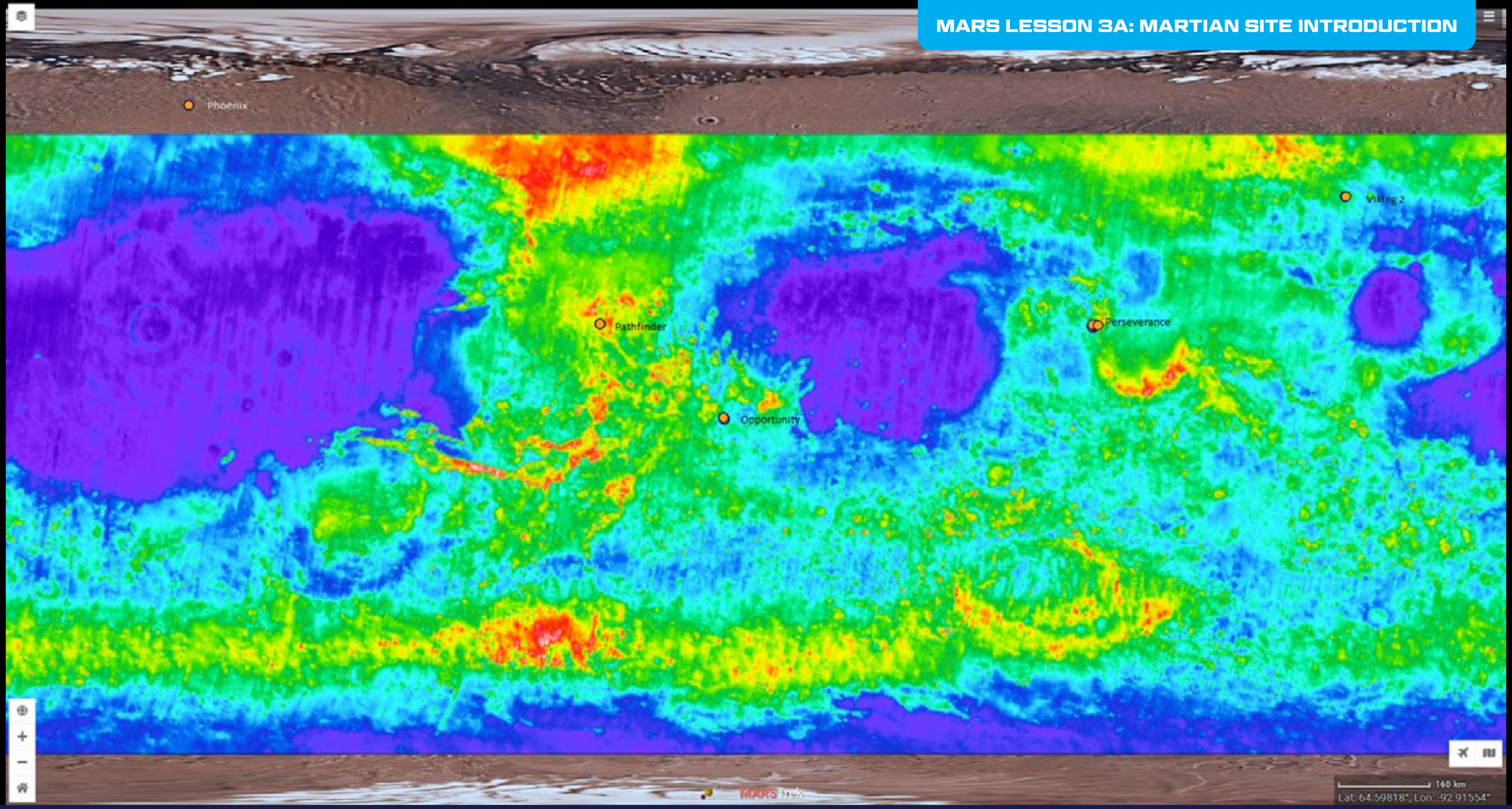
Red indicates about 2-3%, green is 4-6%, teal is 8%, royal blue is about 16-32%, dark blue is 32-64%, and purple is more than 64%.

MASS FRACTION OF WATER:
IMAGE DESCRIPTION



This is a flattened image of a map of Mars with rounded edges. The map shows many textural features on the surface of Mars, like craters and mountains. The map is very colorful to represent the data. The bottom and uppermost sixth of the image are dark blue. Between these dark blue patches there is a light blue patch in the middle of the image. Surrounding the light blue patch is green that then has many medium-sized red patches in it. On either side of the green ring with red patches are more light blue spots with red patches.

Sites are marked by an orange dot. Phoenix is at the upper left of the image and is dark blue. Opportunity is on a teal area right in the middle of the image, sitting almost on the equator line. Pathfinder is on a red area that is about a third of the way above the equator line and to the left of Opportunity. Perseverance is on a green area that is about a third of the way above the equator line and to the right of Opportunity. Viking is to the upper right of Perseverance at a latitude about twothirds of the way up from the equator, on a teal area.



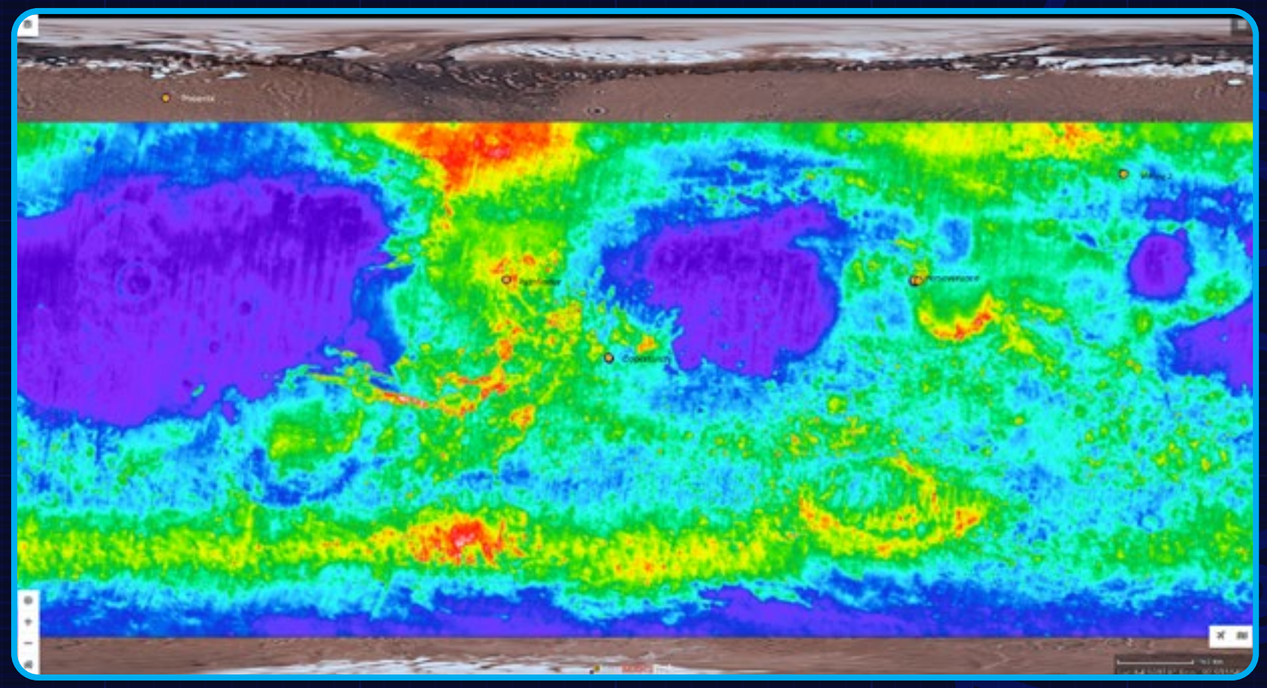
THERMAL INERTIA MAP:

DESCRIPTION OF DATA REPRESENTED

Thermal inertia is the ability of the surface to store heat from the sun during the day and then re-emit it at night to help keep things a little warmer at night. This depends on the properties of the rocks themselves. The sandier the area, the quicker it heats up and the quicker it cools. Bigger rocks warm up slower but also cool off slower, meaning they will be warmer longer into the night.

This is a flattened version of Mars. If you drew a horizontal line through the middle of the image that would be the equator, while the upper and lower parts of the image are closer to the poles.

THERMAL INERTIA MAP:
IMAGE DESCRIPTION



This is a flattened image of a map of Mars with rounded edges. The map shows many textural features on the surface of Mars, like craters and mountains. The map is very colorful to represent the data. The bottom and uppermost sixths of the image show the rusty red color of Mars's surface and in these areas no data is mapped. Between these rusty red patches there is a series of three dark blue to purple patches. The largest is on the left side of the image. In the middle of the map is another patch of the same color about half the size of the first. At the right of theis another blue to purple patch about half the size of the middle patch. Surrounding these patches is a mottled coloring of green, yellow, and teal. There is a red patch between and above the large and medium-sized purple patches.

Sites are marked by an orange dot. Phoenix is at the upper left of the image and is on dark blue. Opportunity is on a teal area right in the middle of the image, sitting almost on the equator line. Pathfinder is on a red area that is about a third of the way above the equator line and to the left of Opportunity. Perseverance is on a green area that is about a third of the way above the equator line and to the right of Opportunity. Viking is to the upper right of Perseverance at a latitude about two-thirds of the way up from the equator, on a teal area.

URBAN PLANNING LESSON 3A:

ETHICS IN URBAN PLANNING

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Define “ethics”
- Define “professional ethics”
- Discuss an ethical dilemma with peers
- Write a response to questions about the ethical dilemma

MATERIALS NEEDED

- **“Ethical Dilemma” sheet**
  1 per student or group (printed) or on screen
  https://drive.google.com/file/d/1bsuw3sPT8FR2eLYuzNwDPKe4KPQclRKM/view?usp=sharing

- **Access to AICP “Ethics Code” webpage**
  https://www.planning.org/ethics/ethicscode

- **Paper and pencil, digital text document, or other equivalent**

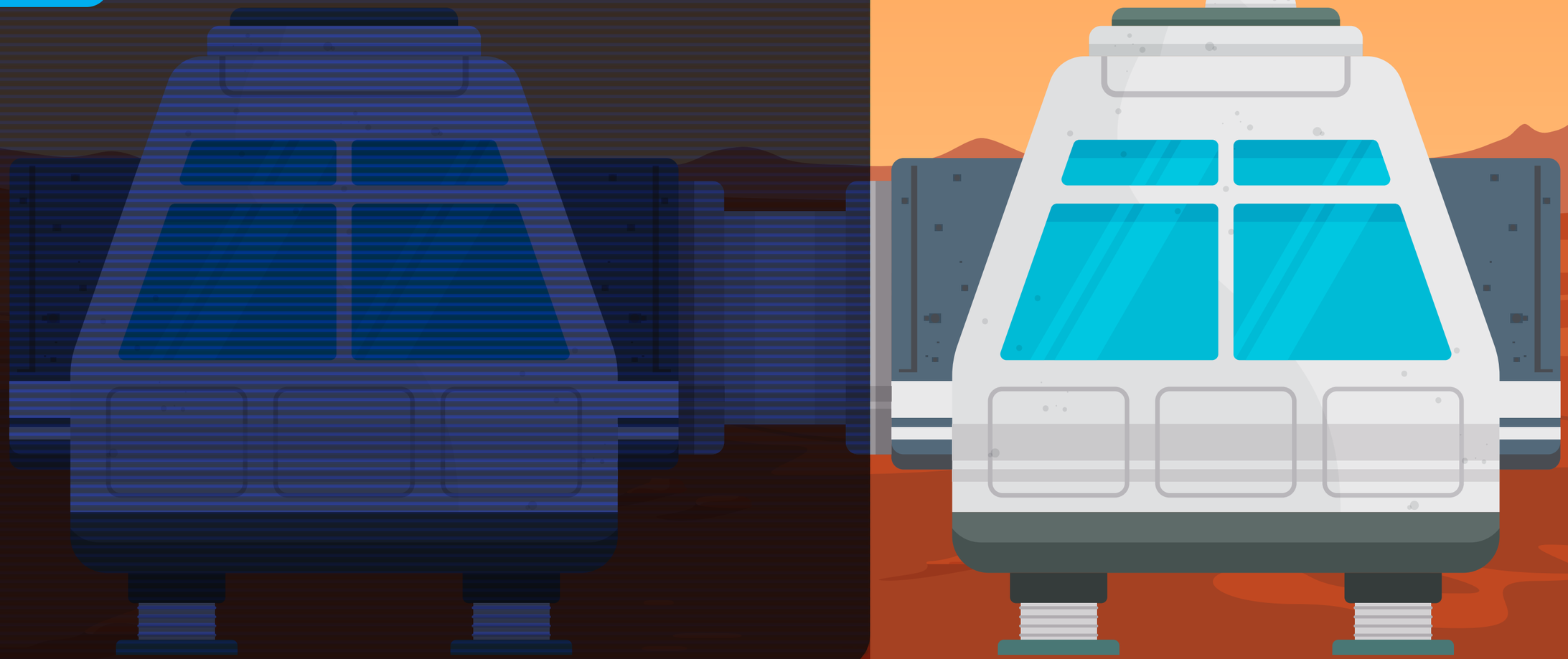
ACTIVITY 1:

AN ETHICAL DILEMMA

TIME REQUIRED: **15 MINUTES**

[Give the students the "Ethical Dilemma" sheet, either on screen or printed on paper.] They will meet Janice Smithson, a fictitious urban planner facing an ethical dilemma. Ask the students (alone or in groups) to read about Janice's situation (based on an APA ethics training document).

Meet Janice



MEET JANICE SMITHSON

About Janice

- Job title: Senior Urban Planner
- Location: Large city nearby
- Works mostly on commercial and industrial projects
- Part of the group that decides land use laws for the city

At Today's Planning and Zoning Meeting

Janice is part of the city's "Planning and Zoning Commission." This is the group that decides the land use laws for the city. Today is their regular monthly meeting. Janice sits down, and Alejandro hands her the list of projects to talk about that day. She sees that the Commission is going to talk about approving a new shopping area for the city. Janice owns property where the new shopping area is supposed to go. She could personally make a lot of money if she votes "Yes" on the change. What should she do?

Text Janice Your Advice

Write a text message to Janice giving her advice about what to do in this situation. Do you think this is a problem for Janice? Why or why not? How should she handle this situation?

DISCUSSION

[Ask students] **So, what do you think?**

- What is going on in this situation?
- Is there a problem? Why or why not?
- If students have trouble identifying the potential issues, use a comparison like them voting for a change that would affect their own grades in school. They would have power over the change and personally benefit from it.

After student discussion, explain that there is a conflict between Janice's roles as property owner and public servant. She is facing an **ethical dilemma**. What are **ethics**? *[Have students respond]* Ethics are the rules of conduct that guide how a person or a group behaves or what people do when faced with a problem. Ethics help people make decisions.

Urban planners have a special code of professional ethics. If ethics guide people in everyday life, what do you think **professional ethics** are? *[Have students respond]*

Let's take a look at the professional ethics code for the American Institute of Certified Planners (https://www.planning.org/ethics/ethicscode). Is there something here that might help Janice make a decision? (Section B.14).

[Discuss] Why does this matter? In planning, decisions impact a lot of people. Who gets a voice and why? Who has power and control? How could some people use their power in ways that other people can't? How can planners help make decisions that take into account all people's interest?

What about on Mars? How might ethics be important there? What kinds of things do you think we should pay attention to? *[Discuss briefly]*

Here are some examples: Who gets to live where? Who gets to own land? Who makes the decisions? What about people from different countries on Earth — might this cause some problems? What about just being on Mars to begin with?

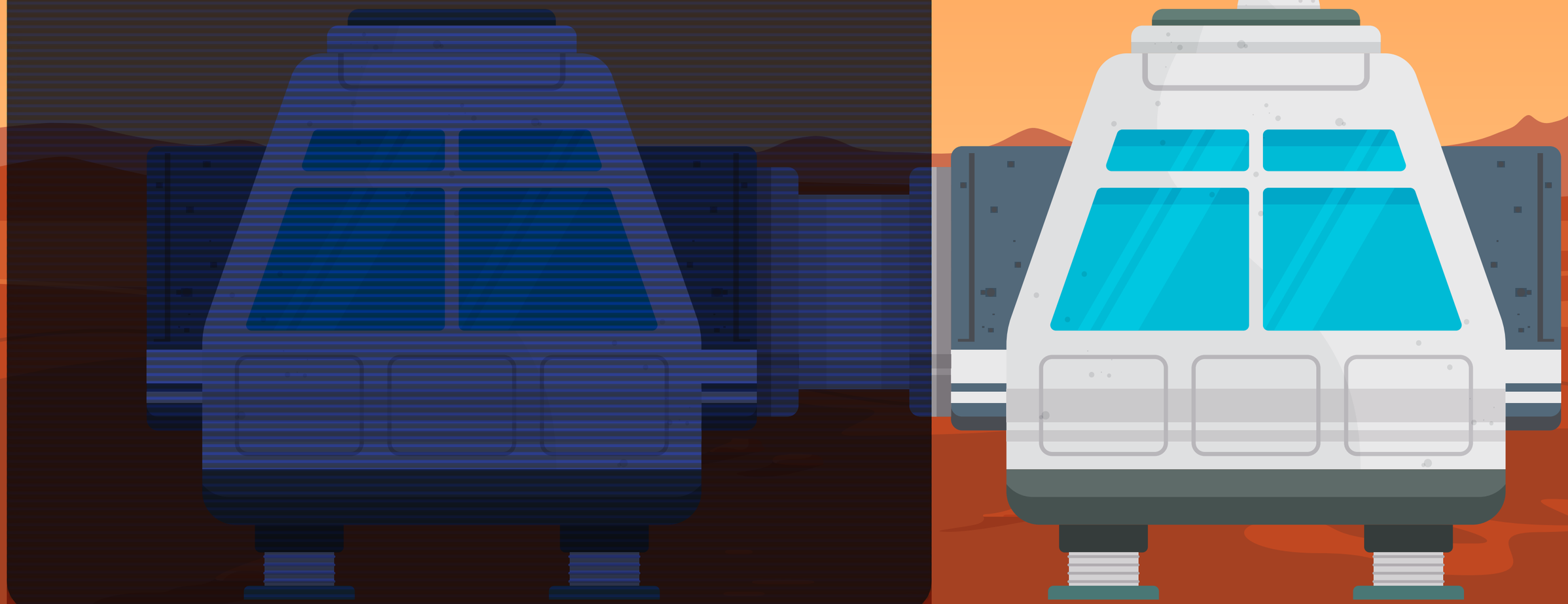
ACTIVITY 2:

WHY DOES IT MATTER?

TIME REQUIRED: **5 MINUTES** TO START; COMPLETE AS HOMEWORK

Individually or in a group, have students write a text message to Janice. They should address three questions:

- Do you think this is a problem for Janice?
- Why or why not?
- How should she handle this situation?



HOMEWORK:

WHY DOES IT MATTER?

Complete Activity 2.

Individually or in a group, have students write a text message to Janice. They should address three questions:

- Do you think this is a problem for Janice?
- Why or why not?
- How should she handle this situation?

MARS LESSON 3B:

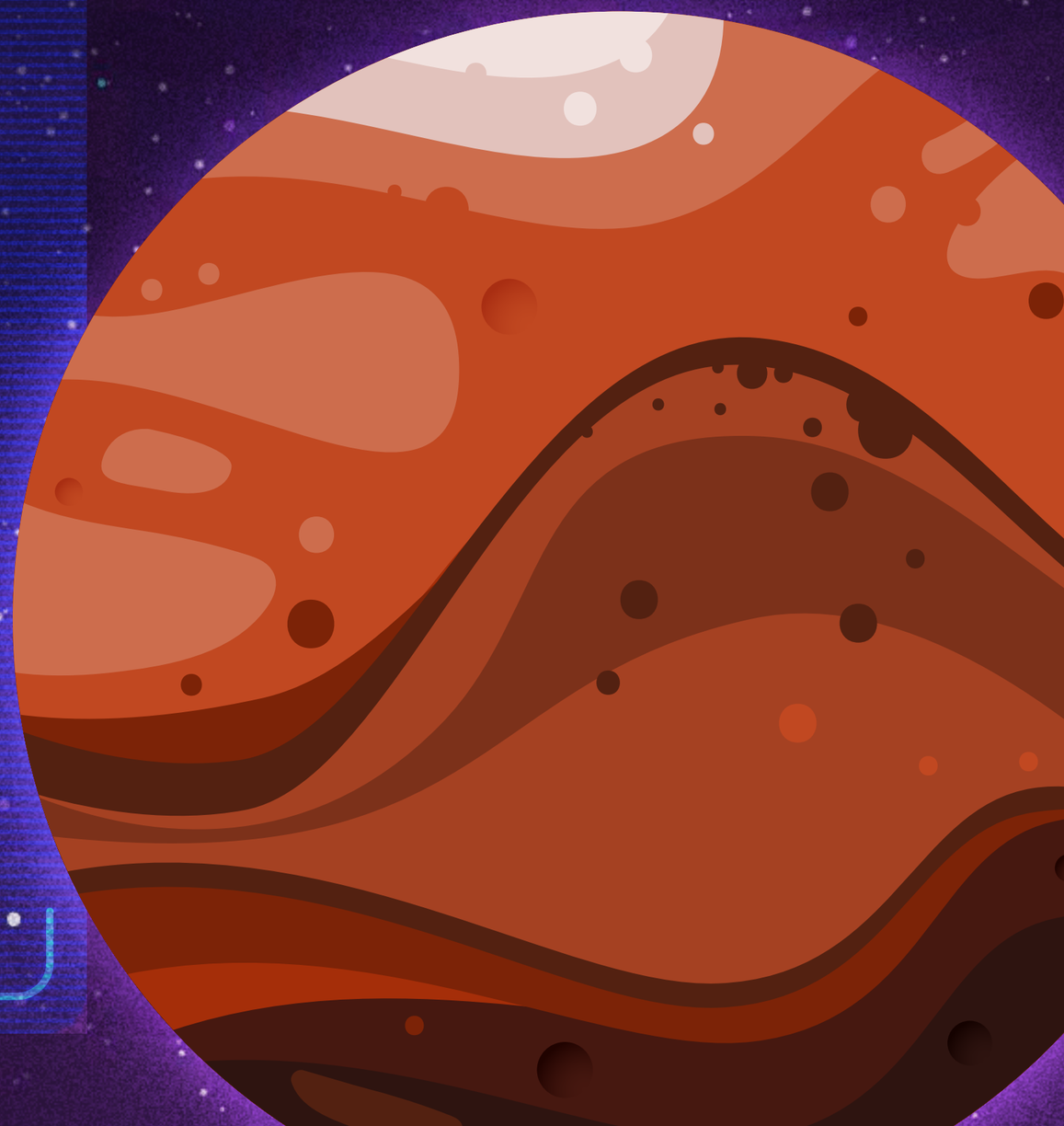
CLASS DECISION ON WHERE TO BUILD

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Explain the different resources available at five different sites for building their cities
- Choose where to build their city, and defend the choice



MATERIALS NEEDED

- **One of these:**
  - Decision Jamboard
  - Or set up a list of landing sites and have students vote with sticky notes in the classroom, raised hands, or another method that works best for you and your students

- **Martian Maps** (used in previous lesson)
  - Dust Index (how much dust accumulates in these regions)
  - Water Ice (buried water ice)
  - Water mass fraction (water embedded in the soil, not as easily extracted as ice)
  - Thermal Inertia (how much heat is retained and reemitted at night)

- **Information cards** (used in previous lesson)

- **Access to video of how to read the maps and information cards**
  https://mediaspace.msu.edu/media/Introduction%20to%20Site%2C%20Maps%2C%20and%20Information%20Cards/1_e86wjti6

- **Filled-out Building Site Ranking sheet saved from previous Mars lesson (3A)**

- **Optional:** Mars Trek

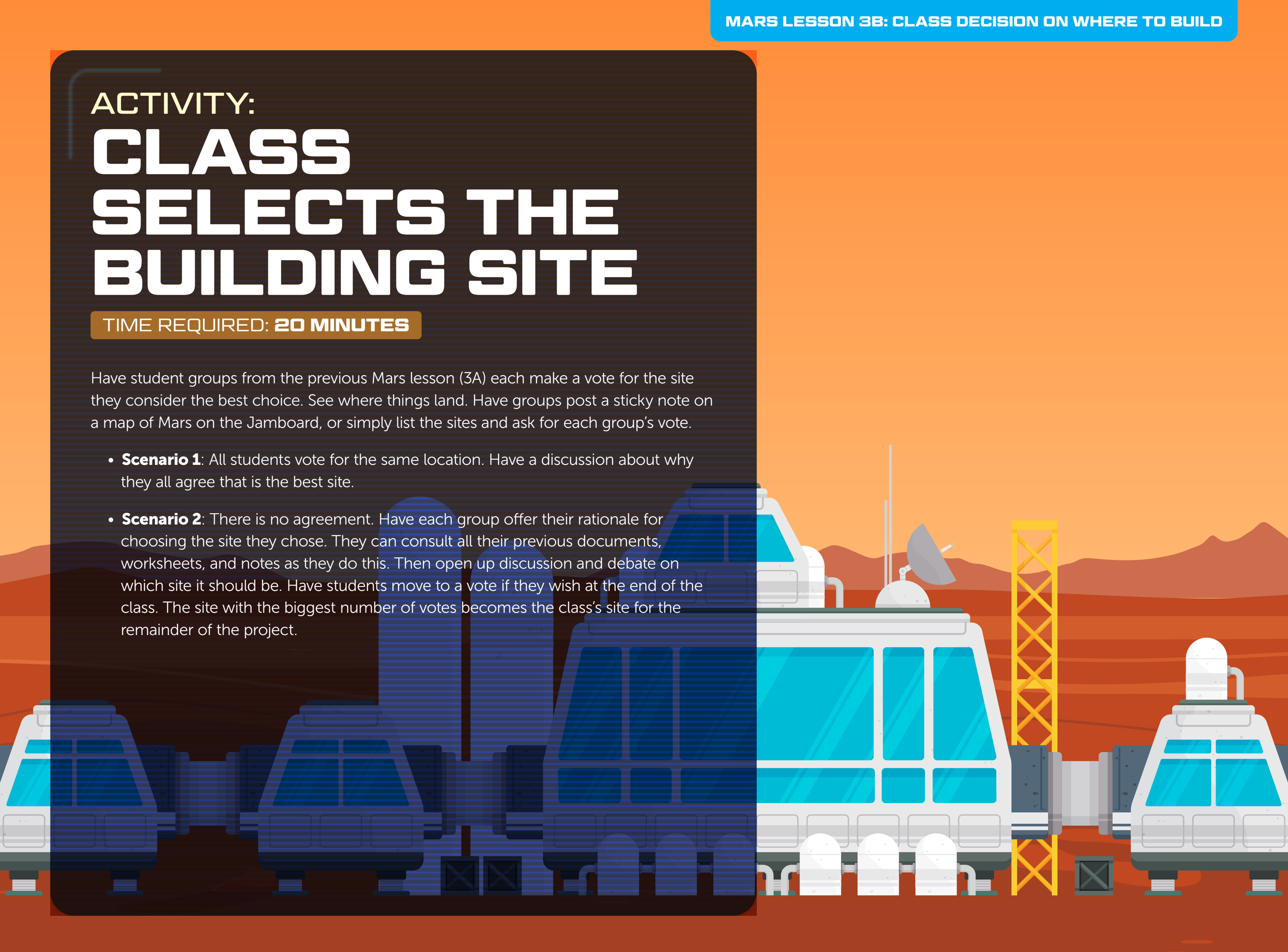
ACTIVITY:

CLASS SELECTS THE BUILDING SITE

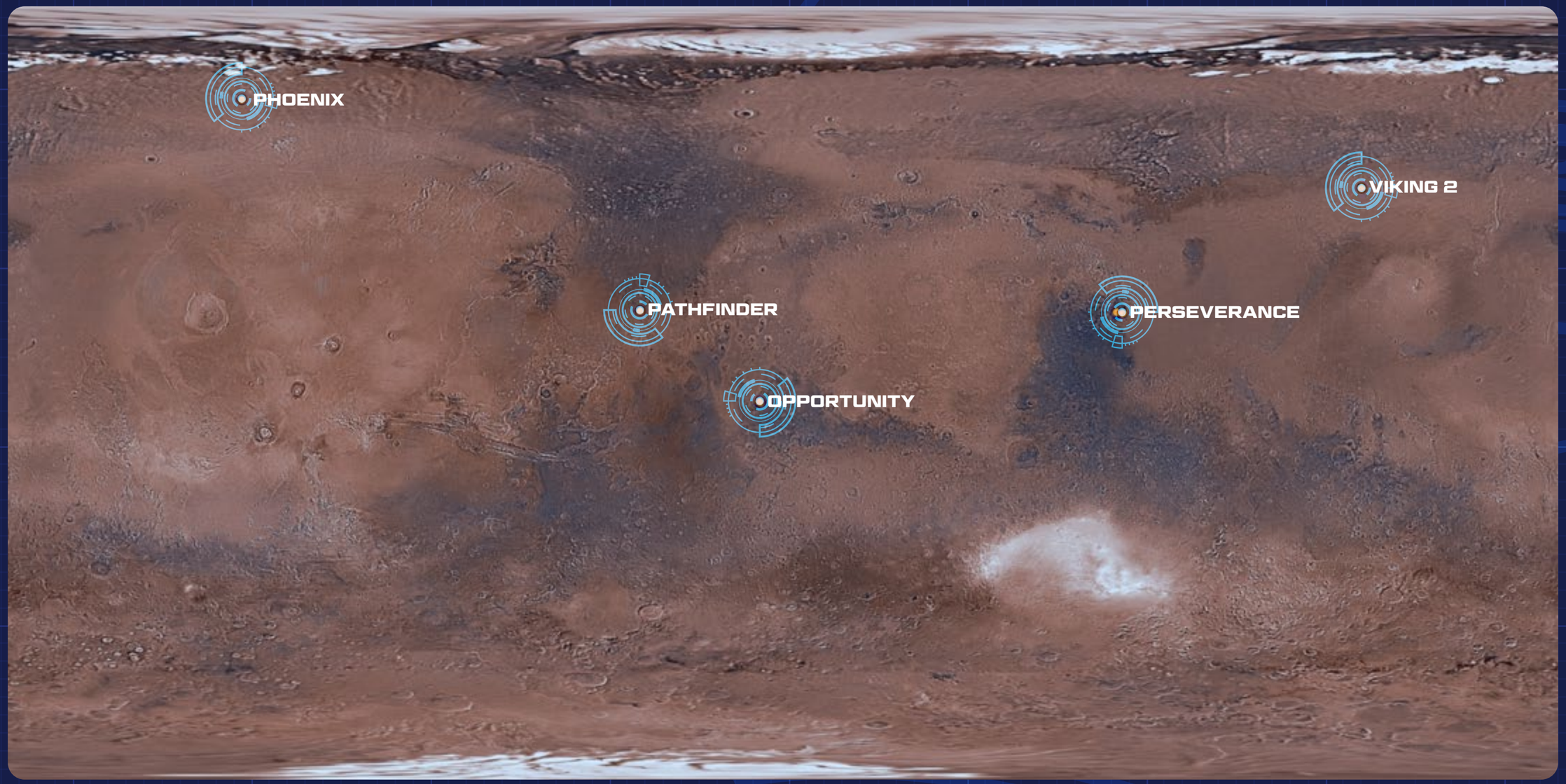
TIME REQUIRED: **20 MINUTES**

Have student groups from the previous Mars lesson (3A) each make a vote for the site they consider the best choice. See where things land. Have groups post a sticky note on a map of Mars on the Jamboard, or simply list the sites and ask for each group's vote.

- **Scenario 1**: All students vote for the same location. Have a discussion about why they all agree that is the best site.
- **Scenario 2**: There is no agreement. Have each group offer their rationale for choosing the site they chose. They can consult all their previous documents, worksheets, and notes as they do this. Then open up discussion and debate on which site it should be. Have students move to a vote if they wish at the end of the class. The site with the biggest number of votes becomes the class's site for the remainder of the project.



LANDING SITES



PHOENIX

Temperature: -144° to -4°F (-98° to -20°C)
Hours of Daylight: 0h to 16h31m
Composition: Unknown, probably basaltic

PATHFINDER

Temperature: -89° to 9° F (-67° to -13°C)
Hours of Daylight: 10h54m to 13h23m
Composition: Probably volcanic basalt

OPPORTUNITY

Temperature: -101° to 43°F (-73° to 6°C)
Hours of Daylight: 11h51m to 12h06m
Composition: Sulfur-rich sedimentary rock, basaltic sand

PERSEVERANCE

Temperature: -115° to 44° F (-83° to 7°C)
Hours of Daylight: 10h56m to 13h20m
Composition: Clay, Carbonates, Volcanic rocks

VIKING 2

Temperature: -184° to 57°F (-120° to 14°C)
Hours of Daylight: 8h10m to 16h02m
Composition: Unknown, probably basaltic

View Google JamBoard

View Printable Worksheet

URBAN PLANNING LESSON 3B:

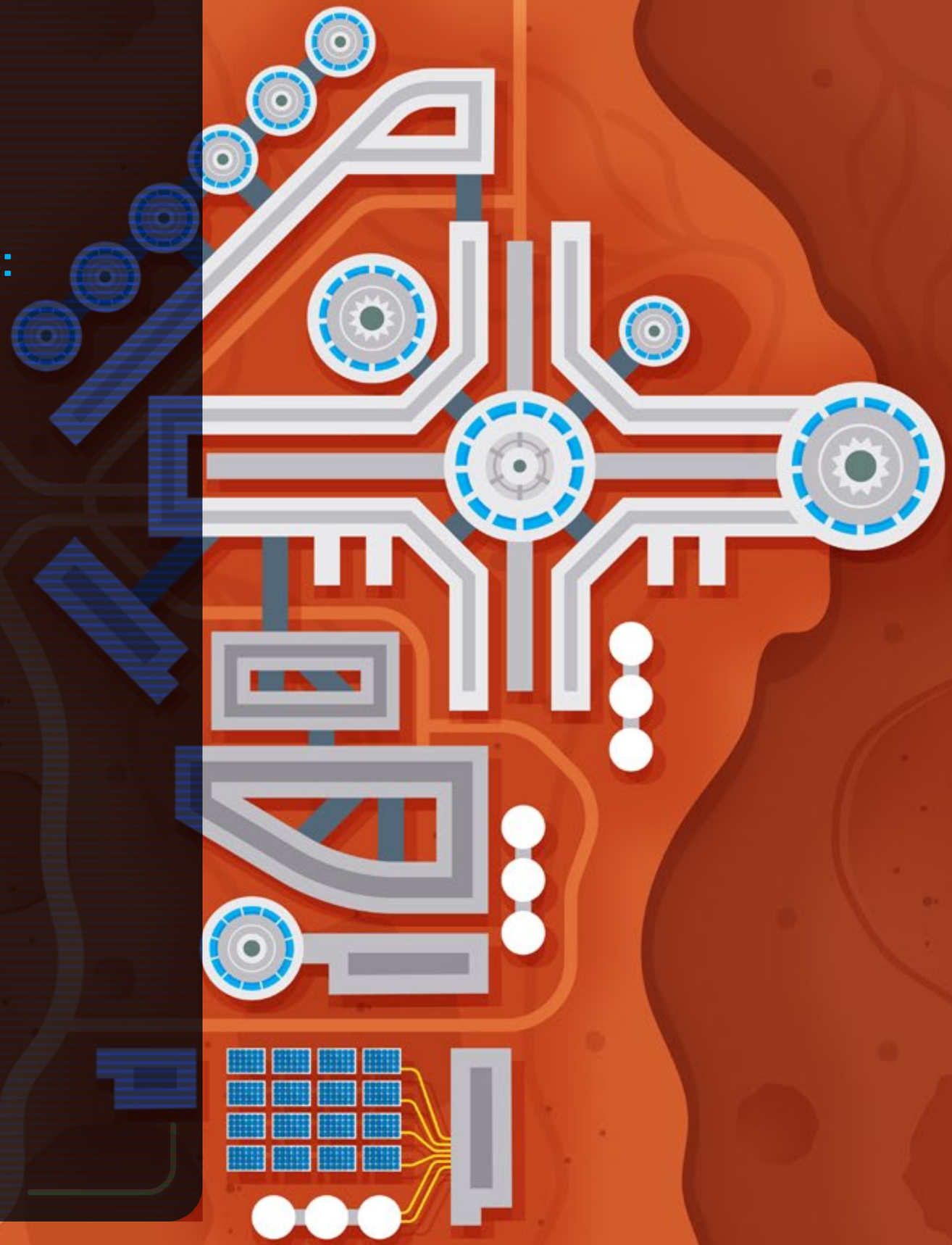
URBAN PLANNING ETHICS ON MARS

TIME REQUIRED: **20 MINUTES**

OBJECTIVES

Students will be able to:

- Discuss ethical issues related to urban planning on Mars
- Collaborate with others to create a set of "Martian Land Use Laws"



MATERIALS NEEDED

- Paper and pencil, digital text document, or other equivalent

REVIEW FROM LAST SESSION

TIME REQUIRED: **3 MINUTES**

Ask students to recall what they learned in the last session (Urban Planning Lesson 3A) about ethics and professional ethics. What are they? Who was Janice and what was her situation about? [Janice faced an ethical dilemma between her roles as property owner and public servant.]

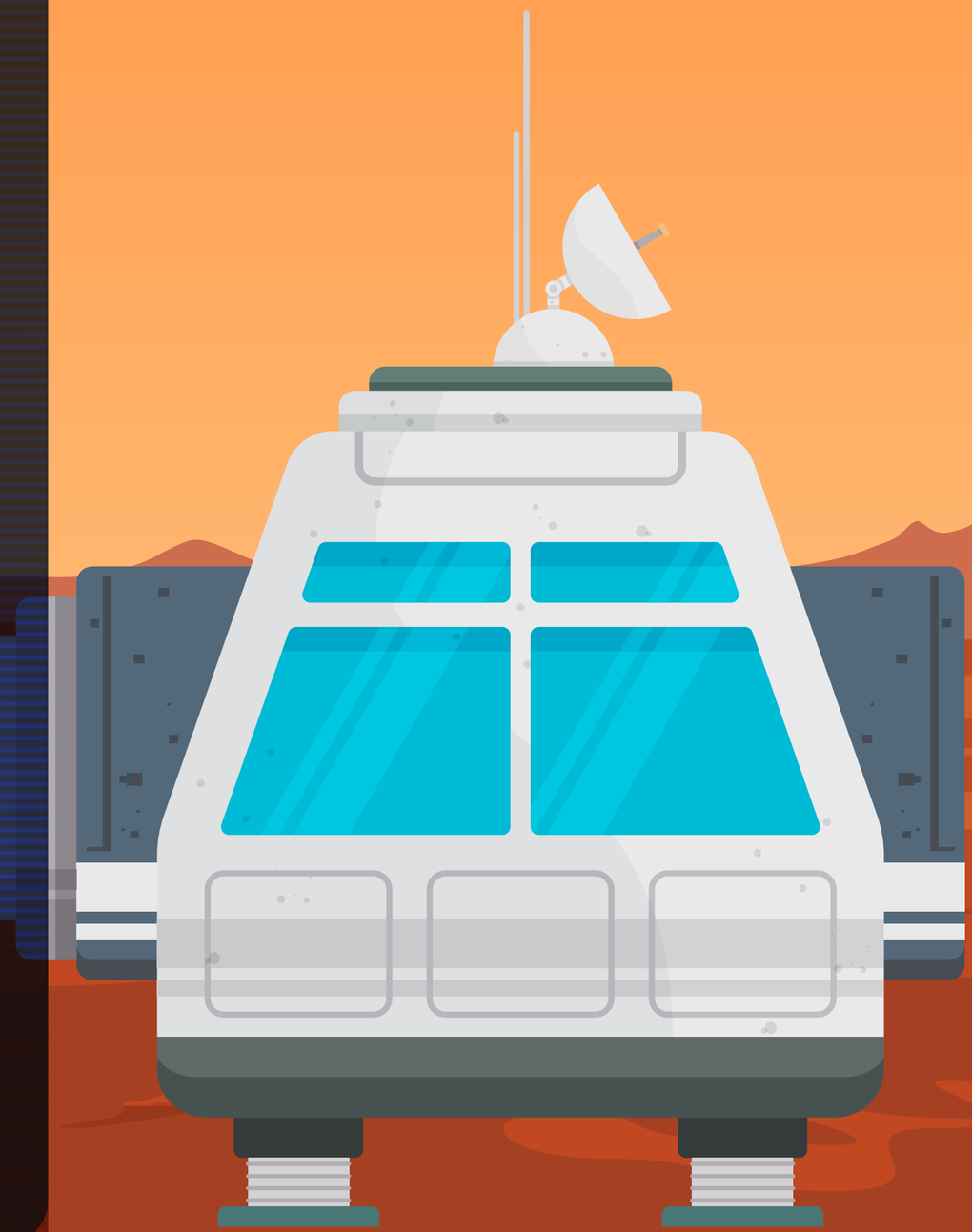
ACTIVITY 1:

DISCUSSING ETHICAL ISSUES ON MARS

TIME REQUIRED: **15 MINUTES**

Building communities on Mars involves a lot of ethical issues. It will take the cooperation of many people to solve these issues. Ask the students to think about these issues and add any more they want to a list:

- What ethical issues are related to the community they are planning on Mars?
- Are the issues the same or different than on Earth?
- Who gets a voice in the planning process, and why?
- What about land ownership? What about other countries? We have rules about Moon ownership, etc. — there is a branch of law called “space law.”



ACTIVITY 2:

MARTIAN LAND USE LAWS

TIME REQUIRED: **10 MINUTES** TO START; COMPLETE AS HOMEWORK

OPTION 1

Using the ideas discussed in the lesson, work together as a class to create a set of land use "laws" for your Mars community. Include information about zoning, land use, ethics, etc. Do research online as needed.

OPTION 2

Using the ideas discussed in the lesson, have students work in pairs or small groups to research different aspects of the land use "laws" for your Mars community. Include information about zoning, land use, ethics, etc. When students are finished, "jigsaw" the information together.

HOMEWORK:

MARTIAN LAND USE LAWS

Complete the "Martian Land Use Laws" activity.

OPTION 1

Using the ideas discussed in the lesson, work together as a class to create a set of land use "laws" for your Mars community. Include information about zoning, land use, ethics, etc. Do research online as needed.

OPTION 2

Using the ideas discussed in the lesson, have students work in pairs or small groups to research different aspects of the land use "laws" for your Mars community. Include information about zoning, land use, ethics, etc. When students are finished, "jigsaw" the information together.

FINAL PROJECT LESSON PLAN

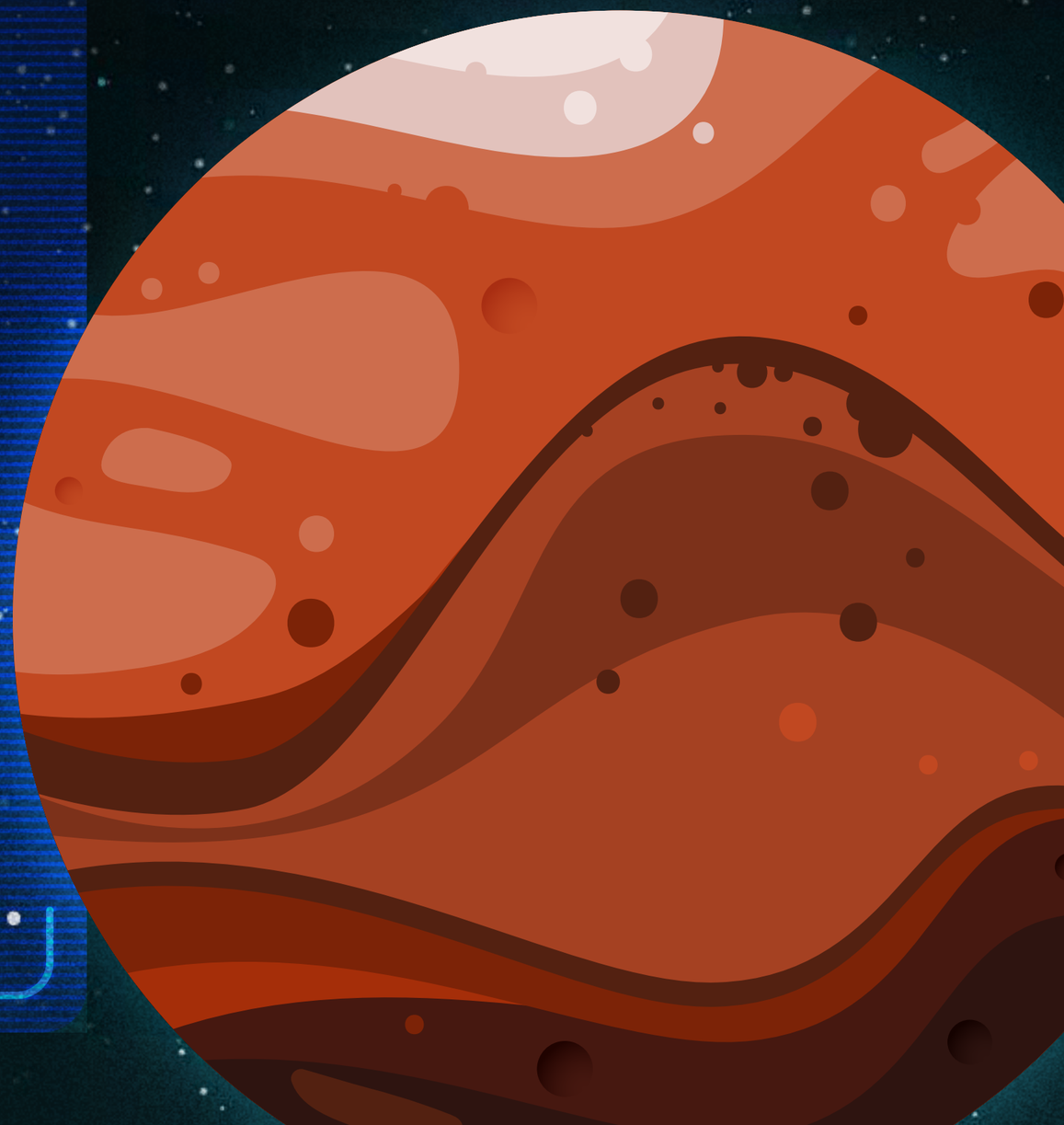
TIME REQUIRED: **FLEXIBLE**

EXPECTED TO TAKE 3 HOURS TOTAL, OVER HOWEVER MANY DAYS YOU HAVE STUDENTS. CAN BE DONE IN PERSON OR ASYNCHRONOUSLY.

OBJECTIVES

Students will be able to:

- Lay out their Martian city according to urban planning principles
- Design their chosen building in their group to address one need that would have to be met for people to survive and thrive on Mars
- Justify their design choices in a written document



MATERIALS NEEDED

- **Aerial Images of chosen Landing Site**
- **Drawing Sheet from Urban Planning Lesson 2B**
- **Writing Prompt** (“About My Martian Building” sheet)
- **Survive and Thrive sheet** (students filled out in Mars lessons 1B and 2A)
- **My Martian Building worksheet**
- **Drawing Template**
- **(Optional) Team Jamboard**
- **Aerial Images of sites**
  - Phoenix **Jamboard**
  - Pathfinder **Jamboard**
  - Opportunity **Jamboard**
  - Perseverance **Jamboard**
  - Viking 2 **Jamboard**

DISCUSSION AND VOTING:

WHICH BUILDINGS TO DESIGN FOR THE MARTIAN CITY

- Open class discussion to decide which buildings students feel they need the most for their city. (The number of buildings is a bit flexible, depending on the number of students and how teachers want to split students into groups.)Working with the teacher, students will list all the possible buildings.
- You may want to limit the total number of buildings students are designing. In that case, have them vote for their top five to ten.. All votes can be aggregated and the top five to are the ones that the class will design for their city. Voting can be done however the teacher thinks best, such as through an online poll, a piece of paper that gets turned in, etc.

ACTIVITY 1:

CREATE A MAP OF THE MARTIAN CITY

1. You can have each student design a building, or have students work in groups to design a building. If using groups, make each group responsible for one building. Teachers can split groups however they feel best works for their students as long as there are five to ten groups, depending on the city.

2. Have students or groups work together to make a 2D map of their city.

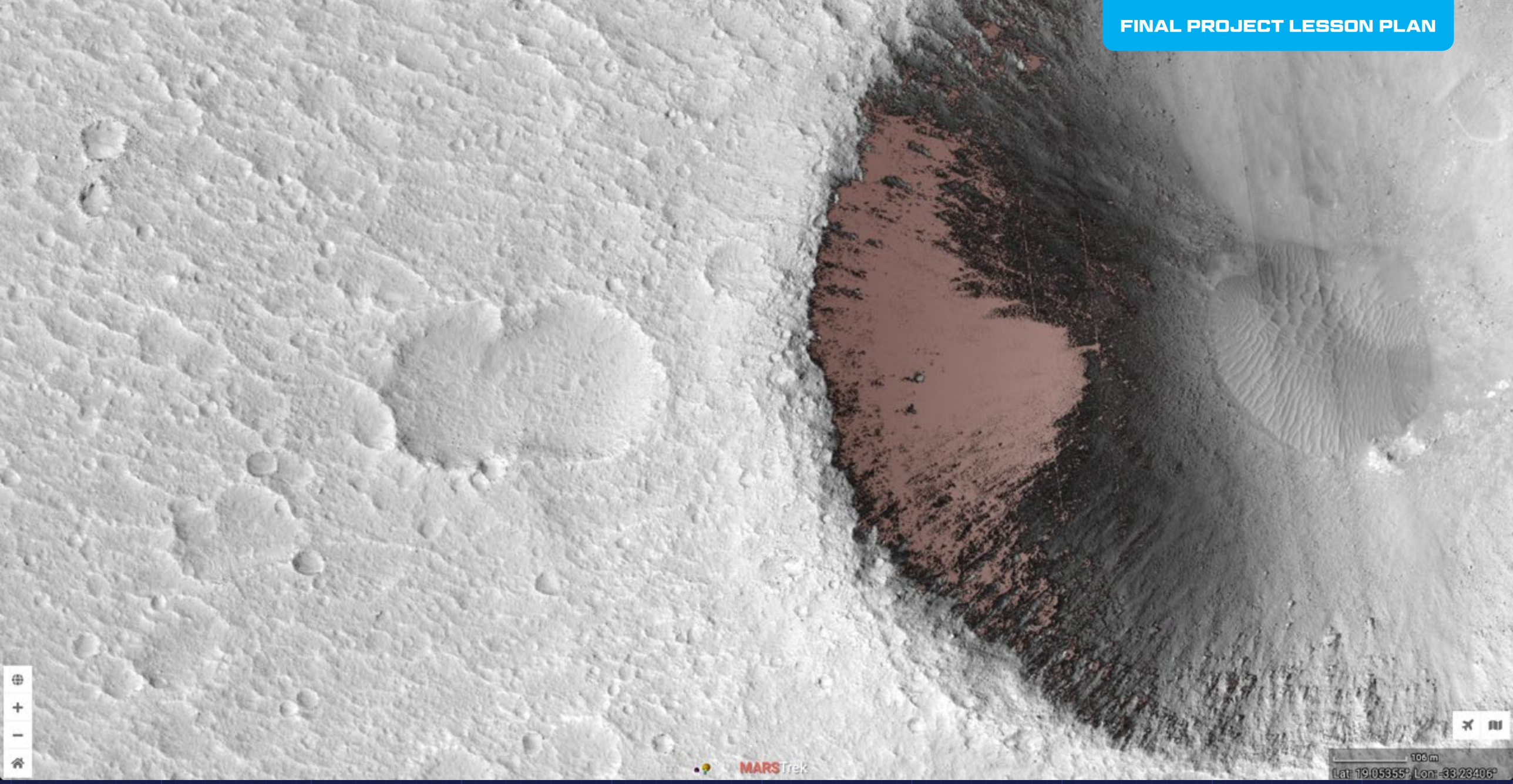
3. Provide students/groups with an aerial image of the site at which they are planning to build their city, and sticky notes (on a Jamboard or in person, whatever works best for you). Have each student/group place their building where they think it should be. If there is overlap, open up class discussion to decide final placement.

AERIAL IMAGE:

PHOENIX LANDING SITE

The image has a scale marker about 1 eleventh of the width that is labeled 106 m.

The ground appears smooth and featureless.



AERIAL IMAGE:

PATHFINDER LANDING SITE

The image has a scale marker about 1 eleventh of the width that is labeled 106 m.

The right third of the image shows about half of a crater that is nearly the same height as the image. The is very smooth inside the crater. The reamining land is unevent with small depressions that rand in size from about half hte size of the scale marker to about the size. There is a larger depression just to the left of the large crater that is about twice as big as the scale marker. That depression looks like two overlapping circles.

AERIAL IMAGE:

OPPORTUNITY LANDING SITE

The image has a scale marker about 1 eleventh of the width that is labeled 106 m.

The right side of the image shows a curved rocky edge of a crater. The remainder of the image shows wrinkly land with some depressions that are about a third the size of the scale marker to the size of the scale marker.

AERIAL IMAGE:

PERSEVERANCE LANDING SITE

The image has a scale marker about 1 eleventh of the width that is labeled 106 m.

On the left the image the ground appears wrinkly. There is a raised feature that is approximately one scale marker in width and two scale markers in length. To the right of the raised feature is smooth ground with two smaller raised featured that are a little less than one scale marker in size. the right side of the image shows more mottled uneven ground.

AERIAL IMAGE:

VIKING 2 LANDING SITE

The image has a scale marker about 1 eleventh of the width that is labeled 106 m.

The ground appears mostly mottled. There is a round depression on the bottom left half of the image that is approximately two scale markers wide. On the right hand side on the upper half of the image is another round depression that is about 1.5 time the scale marker wide.

ACTIVITY 2:

DESIGN A MARS BUILDING

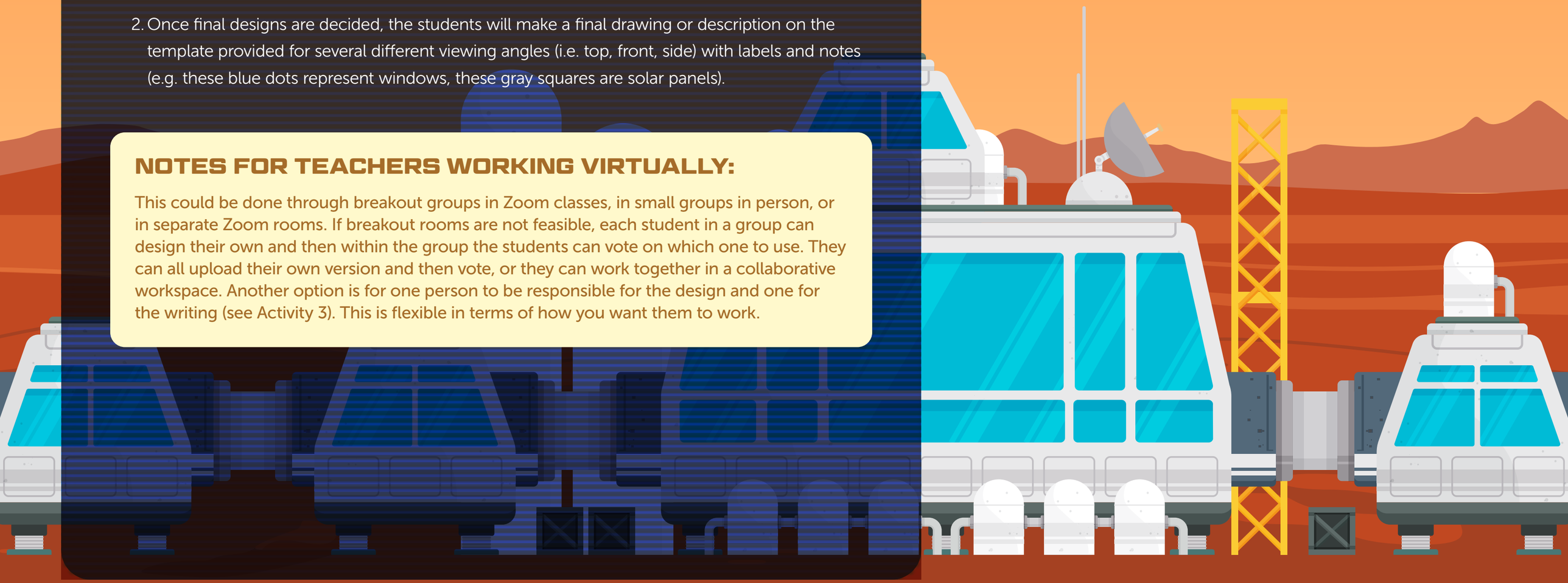
Have students/groups design their buildings using the drawing template.

1. Have students do rough sketches and discuss the overall design they want to go with. The worksheet My Martian Building is provided to help them to think about color, texture, paint, and shape, and guide them through discussion points.Accessibility: For students who may not be able to draw, you can ask them to describe their building in detail.

2. Once final designs are decided, the students will make a final drawing or description on the template provided for several different viewing angles (i.e. top, front, side) with labels and notes (e.g. these blue dots represent windows, these gray squares are solar panels).

NOTES FOR TEACHERS WORKING VIRTUALLY:

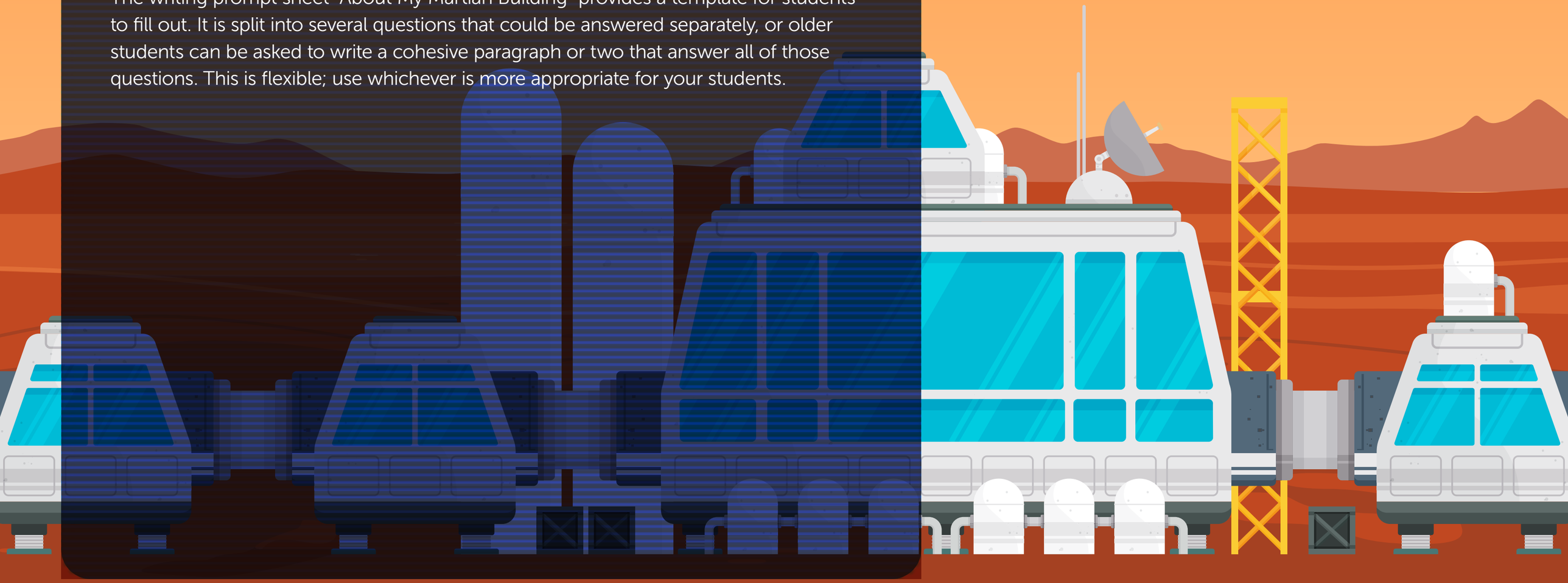
This could be done through breakout groups in Zoom classes, in small groups in person, or in separate Zoom rooms. If breakout rooms are not feasible, each student in a group can design their own and then within the group the students can vote on which one to use. They can all upload their own version and then vote, or they can work together in a collaborative workspace. Another option is for one person to be responsible for the design and one for the writing (see Activity 3). This is flexible in terms of how you want them to work.



ACTIVITY 3:

WRITE A DESCRIPTION OF THE BUILDING THEY DESIGNED

The writing prompt sheet “About My Martian Building” provides a template for students to fill out. It is split into several questions that could be answered separately, or older students can be asked to write a cohesive paragraph or two that answer all of those questions. This is flexible; use whichever is more appropriate for your students.



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Curriculum Authors:
Dr. Shannon Schmoll, Abrams Planetarium
Dr. Denice Blair, Michigan State University Museum

Mars Modeling and Imagery:
Stacey Fox, Michigan State University School of Journalism

Additional Staff Support:
Shane Horvatin, Abrams Planetarium
Nick VanAcker, Michigan State University Museum

Video Production and Editing:
Da'Jah Grant
Alyssa Bradley

Curriculum Guide Layout and Design:
Mike Davis

Accessibility Consultant:
Grey Pierce

Project Evaluation:
Lana Hamilton, SPEC Associates

NASA Partner:
Gerald Voltz, Glenn Research Center

Partner Teachers:
Caleb Miller, St. Johns High School, St. Johns, MI
Victoria Putvin, Eastern High School, Lansing, MI
Kathy Whitford, Holt Lutheran, Holt, MI

Software Used:
WorldWide Telescope - worldwidetelescope.org
NASA Solar System - solarsystem.nasa.gov
NASA Trek - trek.nasa.gov/mars
The National Map - nationalmap.gov

ANSWER KEY

FUN CHALLENGE Page 25-27

Question 1: True or false: people designed the cities we live in? • Answer: **TRUE**

Question 2: Urban planners are: • Answer: **B: People who plan towns and cities**

Question 3: True or false: people can use land however they want? • Answer: **FALSE**

ZONING MATCH GAME DEFINITIONS Page 60

RESIDENTIAL: Where people live.

COMMERCIAL: Where people buy and sell things.

INSTITUTIONAL: Where people get help, learn, or receive governmental services.

PARKS/OPEN SPACE/PUBLIC SPACE: Where people play, exercise, gather, or enjoy nature.

AGRICULTURAL: Where food is grown or livestock kept.

MIXED USE: Used for more than one function.

WORLD BUILDING ON MARS

This material is based upon work supported by the National Aeronautics and Space Administration under Grant/Contract/Agreement No. 193247145 issued through the TEAM II RORR program

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