NSIP Mars Competition

Design a Mission to Mars

Research Project Components

Develop a Mars Mission Proposal with the sections listed below. The maximum length is 1,000 words, including the Resource Credits and Illustrations.

I. Mission Purpose — Briefly state the Mars-related research question or issue and describe how it is relevant to the mission.

II. Accessibility — Describe what is known about Mars, how it is relevant, and why you are interested in this topic.

III. Mission Design — Include the design details of your mission, including spacecraft, instruments, and targets.

Judging Criteria

Mission Design - 40 points

- Design the mission in a way that makes it clear how the mission will be conducted and what will be achieved.

- Include descriptions of spacecraft, instruments, and targets.

- Make the proposal clear and convincing.

- Provide a detailed explanation of how the mission will be conducted and what will be achieved.

- Include visual aids and diagrams to support the proposal.

- Demonstrate scientific accuracy and clarity in the mission design.

- Include a description of how the mission will be evaluated and how the results will be communicated.

- Include a timeline for the mission.

- Include a description of the team's experience and qualifications.

- Include a description of how the mission will be funded.

- Include a description of how the mission will be managed.

- Include a description of how the mission will be evaluated.

- Include a description of how the mission will be communicated.

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This Educator’s Resource Guide provides background information and learning activities to help your students participate in the NASA Student Involvement Program (NSIP) competition “Design a Mission to Mars.”

Use this Educator’s Resource Guide as a supplement to the official NSIP Program Announcement brochure (see Resources page 15), which provides full details on the NSIP Program and entry form to submit your students’ “Mars Mission Proposal.”

The guide is designed for teachers of grades 5-12. This is a wide age range, so feel free to adapt the materials and activities to make them easier or more challenging.

**NSIP “Design a Mission to Mars”**

**Competition Categories:**

<table>
<thead>
<tr>
<th>GRADES 5-8, TEAMS OF 2-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADES 9-12, TEAMS OF 2-4</td>
</tr>
</tbody>
</table>

**TABLE OF CONTENTS**

2 Mars Pathfinder Exemplifies Successful Mission Design

4 Designing a Mars Mission
   • Conduct General Research
   • Ask Interesting Questions
   • Focus the Research
   • Design the Mission
   • Prepare the Entry

6 Background Information on Mars and Mars Exploration
   • Basic Concepts about Mars
   • Mysteries of Mars
   • Missions to Mars

12 Sample Learning Activities
   • Exploring Craters
   • Searching for Water on Mars
   • Finding Life on Mars

15 Resources

16 Mars Map
Mars Pathfinder Exemplifies Successful Mission Design

The Mars Pathfinder mission demonstrates how a dedicated group of scientists and engineers design a mission and learn from the new data it provides.

On July 4, 1997, the world was transfixed by NASA’s dramatic Pathfinder mission to Mars. After a seven month, 309 million mile journey, the Pathfinder spacecraft fired its retro-rockets to slow its tremendous speed, aero-braked into the Martian atmosphere, and deployed its parachute and protective airbags. Then it bounced to a landing on Mars — the first successful return to the surface of Mars since the Viking mission of 1976.

The mission team cheered at the Mission Control Center at Jet Propulsion Lab (JPL) in Pasadena, CA. After some nail-biting delays, Pathfinder’s side panels spread open like a budding flower. The amazing Sojourner rover rolled down the ramp to begin its wandering and exploring of Mars. Images were broadcast live to a TV audience of millions, and were immediately posted on the Internet for scientists and the general public.

This was a miracle of technology — but it was also a triumph for the many scientists, engineers and others who had struggled for years. For example, Donna Shirley led the overall Mars Exploration Program and worked with her team of engineers to design, build and test the rover. Matt Golombek headed the team of scientists who defined the priority research goals, selected the landing site and interpreted the data. Tony Spear managed the Pathfinder mission, coordinating the efforts of a diverse team of very creative, enthusiastic and surprisingly young people.
The Pathfinder mission demonstrates the richness, mystery, joy, challenges and collaborative spirit of science and space exploration. Scientists develop expertise, ask questions, consider ways to gather new data and examine the data for new insights. Engineers struggle with instrument design, integration into a compact spacecraft, orbital mechanics, landing techniques and the challenges of maintaining a spacecraft far away from the nearest repair shop. And all involved work through issues of teamwork in a dynamic environment.

What will your students learn by designing a Mars Mission?
Through this NSIP competition, your students experience some of the same challenges as NASA’s scientists and engineers. Your students use real images and other data about Mars, define interesting questions, and design a mission to Mars to answer the questions. Whether or not your students win the competition, these activities will stimulate meaningful research, enhance science knowledge and develop higher level thinking skills.

In accordance with the National Science Education Standards, your students will:
• Learn core concepts of Earth and Space science
• Develop skills of scientific inquiry
• Experience the unifying concepts and processes of science
• Gain new skills with technology (computers, Internet, image and data analysis)
• Appreciate the multi-faceted roles of science in our society
• Work collaboratively as team members
• Communicate more clearly and effectively

Science is not just facts – it is a way of asking questions and seeking answers.
Designing a Mars Mission

This five-stage process can help you work with your students to conceive and design a Mars mission. However, creativity is encouraged, so feel free to use whatever approach works for you and your students.

I. General Research
Begin by exploring Mars at whatever level of detail is appropriate for your students. They might simply begin with whatever is in the science textbook. Or they might explore Web sites with detailed images of the surface of Mars from past and current missions (see Resources). In this phase, you raise your students’ general level of understanding about Mars and pique their curiosity about the planet.

II. Interesting Questions
Encourage your students to consider not just what is known about Mars but also what is not known (see “Mysteries of Mars” pages 8-9). Make a list of questions that interest your students and review it to determine which (a) are most interesting to your students and (b) could serve as the focal point for the mission they will design. Narrow the list to one or a few core questions.

III. Focused Research
Have your students do more detailed research relating to the question(s). Your students should investigate the relevant science, using images and other data from Mars, and learn about existing or anticipated instruments that might be useful in your proposed mission. As a result of this research, your students select a primary question, further refine it and generate initial ideas on how a mission might gather data to answer the question.
IV. Design the Mission

This is the core of the work. As with NASA’s own missions, your students need to consider two inter-related elements: the scientific research that they propose, and the engineering challenges in terms of selecting instruments and tools that will provide the data they need (and can reasonably fit on a spacecraft). The mission could involve an orbiter, a lander, a robotic rover, a sample return, a human presence or whatever creative idea your students conceive. As per NSIP guidelines (page 3), focus on the science research goals. Briefly describe (but do not provide detailed designs for) the spacecraft, instruments or tools. Think carefully about the data needed in order to answer the research question(s). Remember that a human mission is far more costly and risky, so the ends must justify the means.

V. Prepare the Entry

Finally, your students present their ideas, research and design in their NSIP Mars Mission Proposal, following the NSIP guidelines. The entry will be judged on the quality of the research and mission design, which must be communicated clearly and effectively. Include maps and images indicating optimal landing sites or targets for orbital study, and discussion of why this is an important mission and research topic.
Basic Concepts About Mars

This summary provides basic information about Mars and Mars exploration. You can learn much more through science textbooks, the Web, books from libraries and book stores and reports in the news (see Resources).

Mars is a planet in our solar system.
Earth is the third planet from the Sun; Mars is the fourth. Since Mars is farther away from the Sun, Mars takes longer to orbit the Sun (687 days for Mars versus 365 days for Earth). The surface of Mars is colder than Earth’s (the average temperature is –63°C, ranging from –125 to 22°C).

Mars is smaller than Earth.
Mars’ equatorial diameter is 6794 km, which is about half of Earth’s. Mars has a mass of 6.4 x 10^23 kg, which is about a tenth of the mass of Earth. If you weighed 100 pounds on Earth, you would weigh only 38 pounds on Mars (Gravity is proportional to the mass and inversely proportional to the square of the distance between the planet’s center and the object it is attracting).

The surface of Mars is very dry.
Scientists believe that Mars had liquid water on its surface early in its history (3 to 4 billion years ago). However, there is no evidence of liquid water currently on the surface (although there may be some liquid water under the surface).
The polar regions are the coldest part of the planet. Mars has ice caps that shrink and grow with the seasons. The polar caps are a combination of water ice and carbon dioxide ice, with layers of dust. Earth-based telescopes, such as those used by amateur astronomers, can detect changes in the size of the polar caps.

The atmosphere is extremely thin. Mars' atmospheric pressure is about 1/100th of Earth's. It consists mostly of carbon dioxide (95.3%), nitrogen (2.7%) and argon (1.6%). Oxygen is only 0.13% of the atmospheric composition. Although clouds (carbon-dioxide and water ice) occasionally form, it does not rain. The Martian atmosphere does not block out ultraviolet rays. Therefore, humans could not survive in such conditions without a pressurized space suit, oxygen supply, and protection from the ultraviolet rays.

The forces shaping the surface changed over time. Early in Mars' history, the primary forces acting on the surface were impacts that caused craters, volcanic activity, surface rifting and catastrophic floods. Currently, the primary force is erosion due to strong gusting winds associated with seasonal dust storms.
Mysteries of Mars

Mars is still a mystery planet, with many unanswered questions. Current and future missions to Mars are designed to help scientists answer them. Your students might consider these mysteries as possible research domains for your mission designs.

Water on Mars?
What role did water play in Mars' early history? There is evidence of flooding, but did water accumulate in pools, lakes and oceans? How long was this wet period in the history of Mars? Where did the water go? Is there liquid water under the surface of Mars?

Life on Mars?
Did or does life exist on Mars? We have seen possible evidence of past life in a meteorite that came from Mars, but this evidence is still quite controversial. Could life have formed in the early wet period of Mars' history? Could life still exist in sub-surface pockets of water? Would life have been single cells, like bacteria on Earth, or might it have evolved into multi-cellular or other more advanced life forms? How might we search for fossils from past life on Mars. How do we avoid contaminating Mars with life forms from Earth and vice-versa?

Mission example: Your students might select landing sites that show evidence of water from the past, and then design a spacecraft to dig hundreds of meters below the surface, searching for possible liquid water under a frozen layer of ice.
Surface features?
How has the surface of Mars changed over time? How long were its volcanoes active? Did Mars have plate tectonics, as on Earth? Why is there such a big difference between the heavily-cratered Southern hemisphere and the relatively smooth Northern hemisphere? What caused the huge Vallis Marineris rift valley? What can we learn about the composition and water content of the surface from the different types of craters found on Mars?

Mission example: Your students might plan an orbital mission with a high-resolution camera to study different types of craters to better understand why they differ. The plan might specify which craters to explore, based on existing Mars maps and images and on current understanding of craters.

Atmospheric dynamics?
Why is Mars regularly enveloped by huge planet-wide dust storms? What can we learn about the occasional clouds? How strong are the winds and how have they re-shaped the surface? How does the temperature and composition of the atmosphere change from the surface to the highest levels of the atmosphere? How does the atmosphere change from one season to the next?

Mission example: Your students might propose a balloon-like spacecraft that can float in the Mars atmosphere, carried by winds at altitudes determined by controls on the spacecraft. Your students might also specify which types of instruments to include.

Human presence?
How could humans survive such a long flight to and from Mars (one way is 7-10 months)? What kind of life-support facilities will we need on Mars? What kind of space suits or other protection will we need to explore the surface? Can we manufacture fuel from resources in the rocks and atmosphere of Mars? What types of exploration can best be done by robots instead of humans (and vice-versa)?

Mission example: Your students might design two missions, one robotic and one human, both focusing on the same research topic (such as the search for sub-surface water). Your students might also compare and contrast them in terms of the effectiveness, relative merits and associated challenges.

What other mysteries engage your students?
NASA’S Missions to Mars

The following examples from past, current and future missions illustrate the wide variety in spacecraft design (see Resources for more details). Your students will need to select the type of mission that best meets their research goals. Options include fly-by, orbital, lander, rover, sample return, human missions, and whatever other creative ideas your students might conceive. Depending on the orbital track, it takes about 7 to 10 months for a mission to go from Earth to Mars, traveling at about 25 km/sec.

Past missions to Mars:
Mariner IV (1965) – Mariner IV was the first successful mission to Mars. As a fly-by mission, it zoomed past Mars, taking pictures as it went. It provided the first close-up view of another planet, and showed a barren, cratered surface.

Mariner IX (1971) – Mariner IX orbited Mars, providing the first opportunity to map the entire planet. This revealed the huge volcanoes, including the largest observed to date in the solar system. The volcanoes on Mars have been inactive for hundreds of millions and even billions of years.

Viking I (1975) – Viking I was a two-part mission, with an orbiter and a lander. The lander was the first successful landing on Mars. It monitored surface conditions and conducted biological experiments to search for life (it found no conclusive evidence). The orbiter provided detailed images of the surface which, for the past 20 years, have served as the primary source of surface information about Mars.

Pathfinder (1997) – Pathfinder (see pages 2-3) landed on Mars and its robotic rover explored the area around the lander. It was the first successful rover on another planet. The rover used a spectral analyzer to determine the elements present in rocks. The lander featured a panoramic camera and a meteorology station.
Currently active missions:
Mars Global Surveyor – Currently orbiting Mars, Mars Global Surveyor (MGS) is providing a wealth of new data and images. Its instruments include telephoto and wide-angle cameras, a laser altimeter, a magnetometer, and a thermal emission spectrometer. New images from MGS are available on the Web on an almost weekly basis.

Future missions:
Mars Climate Orbiter – Scheduled for launch in December 1998, this spacecraft will arrive in orbit around Mars in September 1999. The orbiter will carry instruments to monitor temperature, pressure, dust, water vapor, and condensates in the Martian atmosphere, and a camera to observe clouds and dust storms on global and local scales.

Mars Polar Lander – Scheduled for launch in January 1999, the spacecraft will land on Mars in December 1999. This is the first mission ever designed to land in the polar regions. Instruments include a robotic arm to dig into the soil and collect samples for analysis on the lander and a Mars Descent Imager, which will obtain images as the spacecraft descends to the surface.

NASA expects to launch additional missions, each with its own unique set of instruments, with at least one new mission every 26 months, when Mars and Earth are aligned for the most energy efficient travel. NASA is exploring options for a Mars sample return mission, and in the long-term a human mission. Several of these missions involve collaborations with other countries, especially Japan and the European Space Agency.

Mars Exploration Timeline

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Sample Learning Activities

This section describes learning activities presented as sample research themes to help your students get started.

Research Theme Sample 1: Exploring Craters

In this activity, your students use the Web to explore sample images of the surface of Mars and learn about the status of current missions to Mars. This leads to questions about Martian craters. A similar approach could lead to other Mars-related topics.

I. Learn about the Mars Global Surveyor mission.
Log on to the NSIP Web site (www.nsip.net) which serves as a central entry point into a rich variety of Mars-related Web sites. From this site, go to JPL’s Mars Web site, JPL is the Jet Propulsion Laboratory, NASA’s lead center for the Mars missions. This site provides the current status and recent findings of active Mars missions, such as Mars Global Surveyor (MGS). Use this site to read about the status of MGS, learn about its design and instruments and look at some of the most recent sample images.

II. Study some sample images.
Select a few of the images that seem especially interesting. Download and print them. Have your students study these images, try to identify features such as craters, volcanoes and valleys and think about what might have formed these features. Use the captions, your science textbook, books about Mars, the Web site or other related sources to help your students develop a better understanding of the features in the sample images.

III. Focus on craters.
Perhaps your students have shown a special interest in craters which cover much of the surface of Mars. Have your students compare the sizes, shapes and locations of the craters. For example, some craters have clearly defined edges, others have smoothed edges and others appear to ooze out from the edges. Ask your students what might cause these differences.

IV. Try some classroom experiments.
Have students model some of the features they see. They might make a tray of mud and then drop rocks of different sizes into the mud, to simulate crater formation. Try different consistencies of mud or different heights for the rocks, or throw the rock at a glancing angle. These classroom experiments help students understand the planetary impact processes.

V. Define the research question for your mission.
Your students might notice that Mars’ Northern hemisphere is less heavily cratered than the Southern hemisphere. Have your students examine these differences more closely. This might lead to a research question for your mission, such as “Why is there such a striking difference in crater density between the Northern and Southern hemispheres?”

VI. Design a mission.
This research question in turn might lead your students to design an orbital mission to get detailed images from the two hemispheres for a comparative analysis, or a surface exploratory mission with two teams of geologists, each collecting surface data from one of the hemispheres.
I. Start with the Mars Pathfinder landing site.

The Pathfinder mission is a good starting point for studying water. Scientists speculate that there were major floods of the area around the landing site a few billion years ago and designed Pathfinder to gain data to support or refute this theory.

II. Trace the floods.

With this initial background on Mars Pathfinder, have your students examine evidence of flowing water in images and maps of this region of Mars (see images above and on page 10). For example, your students will see “tear drop” shapes around craters that were probably caused by water flowing around craters. With a larger view of the region, your students can trace the 1,800 kilometer long Ares Vallis channel that carried immense amounts of water in a series of short-lived floods. For more details on how to trace this flood, read “Images from Mars and the Stories They Tell,” available through the NSIP Web site.

III. Model flowing water.

Make a stream table in your classroom, using a long tray such as an inexpensive wallpaper tray. Fill it with sand roughly one inch deep. Then slightly elevate one end and slowly pour water into it. Notice the erosion pattern. Experiment with different slopes of the tray, pouring water at different rates, placing objects on the sand, etc. Try to replicate the tear-dropped shape of water flowing around an object, as seen in the Pathfinder landing site image.

IV. Find other evidence of water.

Using other images of Mars, have your students find other possible evidence of past water on Mars. Find other valleys that might have carried water, mud flows around craters or possible evidence of shorelines. Study examples described by Mars scientists and then have your students search on their own for similar evidence in other images.

V. Design a mission.

Your students might decide to focus their mission on extending this search for evidence of past water. For example, they might select specific sites that have the most compelling evidence of past water as seen in the orbital images, and then recommend robotic rover missions to those sites. The mission design would include images showing the specific target locations, and a description of the specialized cameras and instruments that the rover(s) would need.
I. What is life?
First, ask your students to define life on Earth. Their answers reveal their assumptions about the nature of life. For example, definitions might include only "higher" life forms such as animals and humans, or might include extremely small single-cell organisms. Then ask your students to list the requirements for life to emerge on a planet. Earth-centric answers focus on Earth's unique combination of land, air, water, solar energy and a suitable temperature range. Universal answers would be more general.

II. Where is life on Earth?
Ask your students to describe where life exists on Earth. The obvious answers focus on areas where we see vegetation and animals thriving. The less obvious answers include extreme environments such as the tallest mountains, the deepest parts of the ocean, the cold polar regions, the hot deserts, the upper reaches of the atmosphere, and deep within the surface of the Earth.

III. Are there potential barriers to life on Mars?
Have your students list potential barriers (or challenges) to life on Mars. For example, there is no liquid water on the surface of Mars; the atmosphere is very thin and has very little oxygen; there is no ozone layer to protect life from lethal radiation. Speculate on how life on Mars might evolve unique solutions to these problems. Also, consider how Mars might have been a more conducive environment a few billion years ago, when it was warmer and wetter.

IV. Look for life on Mars.
Given these challenges to the emergence of life, where should a Mars mission look for either fossils or current life? Have your students develop a list of possible environments for life a) in the ancient past when Mars had surface liquid water and b) in the present. These questions focus on environments with liquid water since it is such a useful (if not essential) factor in the emergence of life.

V. Design a mission.
A mission searching for fossils might target places with the most compelling evidence for lakes that lasted for an extended period of time or your students might search for current life, first through an orbital reconnaissance to detect sub-surface water, then with a human mission to the surface with drilling equipment and a base camp with advanced microscopes and equipment for biological analysis.

Research Theme Sample 3: Searching for Life on Mars
Humans have long been fascinated with the prospect of life on Mars. This image shows what some believe may be a "nano-fossil" — possibly an extremely small single cell life form found on a meteorite from Mars. However, others believe it is too small to have been alive. This controversy points out the importance of on-site information directly from the Martian surface or a sample return mission.
Resources

NSIP Competition Announcement
Full details for the NSIP competition are presented in the official NSIP Competition Announcement (EP-1998-10-367-HQ). To get a copy:
• download from the NSIP web site, or
• call to request a printed copy (800-848-8429, toll free)

NSIP Web Site
The NSIP Web Site provides additional information, learning activities and linkages to sites with Mars images, data and other resources (including all web sites listed here).
www.NSIP.net

NASA Educational Resources
NASA has a multi-faceted education and public outreach program, including a comprehensive web site, printed educational materials, image sets and other resources.
NASA Home Page – www.nasa.gov
NASA Spacelink – spacelink.nasa.gov
The guidebook – How to Access Information on NASA’s Education Program, Materials and Services (EP-1998-03-345 HQ) is available through Spacelink)
For further information, contact your local NASA Educator Resource Center, as listed in the NSIP Competition Announcement and website.

Mars Web Sites
Mars Images and Maps
JPL’s Mars Web Page
marsweb.jpl.nasa.gov
Center for Mars Exploration
cmex-www.arc.nasa.gov
NASA’s Planetary Photojournal
photojournal.jpl.nasa.gov
Planetary Data Set
www-pdsimage.jpl.nasa.gov/pds
Malin Space Science Systems
www.msss.com
NASA Image Exchange
nix.nasa.gov

Mars Education Materials
JPL’s Mars Education Program
marsweb.jpl.nasa.gov/education/table-contents.html
Mars Team Online
quest.arc.nasa.gov/mars
ASU Mars K-12 Program
emma.la.asu.edu/neweducation.html
Using Mars Images in Education
www.trec.edu/handson/v97/images/mars.html

Other Mars Web Resources
JPL’s top-level web site
www.jpl.nasa.gov
Goddard’s list of Mars links
nsidc.gsf.nasa.gov/planetary/planets/marspage.html
Hawaii Astronomical Society
www.hawaiiastsoc.org/solar/eng/mars.html
Whole Mars Catalog
www.rimms.com/aero/mars/catalog.html
Planetary Society
planetary.org

Mars e-mail Listserve
For e-mail news and progress reports on the Mars 98 missions, send an e-mail message to: jplnews@jpl.nasa.gov.
Leave the subject field blank, and type: subscribe mars98
in the body of the message.

Mars and Astronomy Books

Periodicals
The Planetary Report
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106-2301
phone (626) 793-5100
Mars Underground News
The Planetary Society, see above address

Posters
Two Faces of Mars, Item #1338, $10.95
MarsScape, Item #1248, $19.95
Both available from:
Spaceshots
26943 Rutherford Ave. Suite R
Santa Clara, CA 95051
(800) 272-2779
www.spaceshots.com
An Explorer’s Guide to Mars, Item #505, $6.00,
Available from:
Planetary Society, see above address

Maps from the U.S. Geological Survey
Topographic Map of Mars
(1:25,000,000) [1 map] $96
Topographic Map of Mars
(1:15,000,000) [3 maps] $2160
Map of Olympus Mons to Aris Vallis
1-1618
Olympus Mons Volcano
1-1379
Close up of Tharsis volcanoes
1-1922
Valles Marineris, the Martian Grand Canyon
1-1253
Channels and water eroded landforms
1-1652
Map of region where Pathfinder & Viking landed
1-1551
Close-up of Pathfinder’s landing site
1-1345
All maps available from
USGS [5.00 each map, 3-4-week turn around]
Box 25286
Federal Center, Building 810
Denver, CO 80225
(800) 435-7627
Map of Mars

- Olympus Mons (largest volcano in the solar system)
- Ares Vallis Channel from ancient flooding
- Pathfinder landing site
- Viking I landing site
- Valles Marineris (1800 km long rift valley)

Scale at equator: 60 km/mm
Design a Mission to Mars