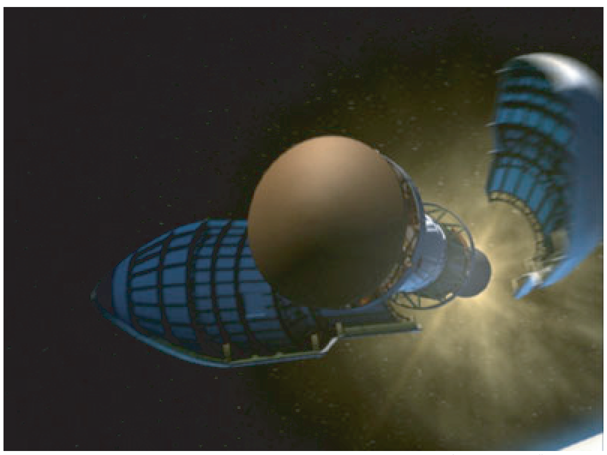
Marsbound!

Mission to the Red Planet

Student Handbook and Activity Guide



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Introduction

Have you ever wanted to travel to Mars? Have you wondered what goes into the planning of a mission to Mars? In this set of activities, you are going to find out! You and your team have been selected to help NASA design a potential mission to the martian surface. You must make your recommendation carefully, keeping in mind all the science and engineering considerations that go into planning a successful mission. Just like NASA mission designers, you will have a "catalog" of mission hardware you can choose from. Also, just like NASA mission designers, you will have a budget that you must keep your costs under! Good luck planning your mission to the Red Planet!

Overview

The activities included in this book are divided into five general sections. The first two sections will teach you how to choose your **science goals** for a mission to Mars. The science goals clearly lay out what you hope to achieve by performing this mission. Your team will work together to decide on these goals and will develop the justification for them. When your design is complete, your team will send these goals and the reasons for them to NASA as part of your recommendations.

The third section will give you information about restrictions on your mission due to the hardware – the spacecraft, rocket boosters, instruments, and other systems – that you are going to send to Mars. These restrictions or limitations on your mission design are called **engineering constraints**. You will need to keep these constraints in mind as you design your spacecraft.

In the fourth section you will actually "build" your spacecraft using a set of "equipment cards". Each of these cards contains a picture of each spacecraft or instrument system and a description of what it does.

Along the right side of each card are three numbers in circles. The number with the "weight" represents the **mass** of the system. The more mass your spacecraft has, the bigger your rocket booster will have to be to get it to Mars. The number with the lightening bolt represents how much **power** the system needs to function. You will have to make sure that your spacecraft provides enough power to run everything onboard! Finally, the number with the dollar sign represents the **cost** of the system in millions of dollars. You must stay within your budget!

In the final section, you will bring all of your team's work together into a report that you will submit to NASA's *Marsbound!* website as your recommendations for NASA's next mission to Mars.

Science Goals

There are many reasons to explore the planets in our Solar System. One of the main reasons we explore is because humans are, as a species, curious beings. We have always had the desire to know what is over the next hill or the next horizon. It was the curiosity of the early explorers that directly led to the discovery of the lands where we make our homes today. The exploration of space does not just satisify our curiosity, however. Many of the **"spin-offs"**, products that have been developed as a result of space exploration, become a part of our daily lives. Cellular phones, rechargeable batteries, portable computers, Velcro, live television, weather satellites, pacemakers, and in-the-ear thermometers are just a few of these spin-offs.

When designing a mission to a planet, mission scientists are not usually thinking about what spin-offs may be produced from the mission. Instead, mission planners have definite **science goals**, questions about the planet that they would like to have answered by the mission. For instance, there are literally thousands of questions that could be asked about Mars alone, so NASA has organized its program of Mars exploration around a common strategy: **"Follow the Water"**. Water is the thread that ties together all four of NASA's main themes for the study of Mars. These themes are:

1. Determine if life ever arose on Mars. All life, as we know it, requires water to survive. In fact, on Earth we have found life wherever there is water, even in places we didn't think life could exist, such as the frozen deserts of Antarctica. Is the same thing true of Mars? Because of the low temperatures and thin atmosphere of Mars today, we know that there is currently no liquid water on the surface of the planet. But was that always true? Some evidence from missions to Mars has indicated that Mars was once warmer and wetter than it is today. Further evidence is needed to settle this question.

2. Characterize the climate of Mars. If we can understand what the climate of Mars is like today and how it changes, we will have a better idea of what the climate of Mars was like in the past. The atmosphere of Mars is mostly carbon dioxide, but two other important components are water vapor and dust. By studying the clouds and dust storms in the martian atmosphere and the patterns of wind-blown dust on its surface, we can begin to understand how the weather changes on Mars during its different seasons. With enough information of this type, we can begin to create a picture of the overall climate of Mars now and what it may have once been like.

Science Goals (cont.)

3. Characterize the geology of Mars. Rocks and minerals on the surface of Mars can tell us a great deal about the planet's past. By studying the **surface morphology**, the patterns and types of features found on the surface, we can find a permanent record of the history of Mars in its rocks. Also, by studying the patterns of ancient channels we can identify where water may have flowed on the surface in the past. Certain minerals only form in liquid water. Even though any water on Mars seems to be gone now, finding these minerals can give us clues as to how much water may have been on Mars in the past and where it might have gone. Craters on Mars can also help us determine the relative ages of different areas on the surface, helping to establish a "timeline" of geological events on Mars. Finally, Mars is home to geological features that dwarf anything found on Earth: It has both the largest volcano and the largest canyon system in the entire Solar System! All of these geological features provide clues we can use to uncover the Red Planet's past.

4. Prepare for human exploration of Mars. As said before, humans are naturally curious. No robot will ever have the flexibility of a human explorer, so someday we will want to travel to Mars ourselves so that we can study the planet and its history directly. Because of the difficulty of the journey and the large number of challenges that must be faced in order to undertake it, robotic spacecraft must pave the way for their human counterparts to follow later. One important task is to study new techniques for entering the martian atmosphere and landing on the surface. It is also important that we understand the dangers humans will face on the surface of Mars and how they can protect themselves from these dangers. How will the basic needs of water, food, and shelter be met? Mars has no planet-wide magnetic field to shield humans from the dangerous radiation emitted by the Sun. How can humans on Mars protect themselves from this radiation? What kind of landing site is suitable for a spacecraft – robotic or human-piloted – to land upon? All of these questions and more must be answered before human beings can satisfy their urge to explore and actually safely travel to Mars themselves.

In the activity that follows, your team will be asked to choose the science goals that you hope to achieve during your mission. Choose wisely, and keep thinking about how your goals will fit into NASA's overall plan for the exploration of Mars. Your team must be prepared to justify its decisions when you defend your mission plan to your classmates!

Activity 1: Sample Science Goals

Here is a list of some of the science goals being studied by Mars scientists. For each science goal, write the numbers of NASA's "Follow the Water" strategy that you think these will fall under. Keep in mind that each goal may apply to more than one part of NASA's strategy! Discuss with your team why you think each of these topics might be important and how it would help answer the questions raised in NASA's Mars Exploration Program.

NASA's "Follow the Water" Strategy for Mars Exploration

1. Determine if life ever arose on Mars
2. Characterize the climate of Mars
3. Characterize the geology of Mars
4. Prepare for human exploration of Mars

Craters

___ What kinds of craters are on Mars and how were they formed?
___ How old are the craters on Mars?
___ How are martian craters different from craters on the Moon?
___ Have martian craters been eroded by wind or water?
___ Were some of the craters on Mars ever flooded?
___ What kinds of rocks make up the ejecta from martian craters?
___ Has the amount of cratering on Mars changed over time?

Volcanoes

___ What types of volcanoes are on Mars?
___ Does Mars have moving continental plates?
___ When and how often did the martian volcanoes erupt?
___ Have martian volcanoes been eroded by wind or water?
___ Has the lava from martian volcanoes been mixed with water?

Plains

___ Were the northern plains on Mars once a huge ocean?
___ Why is the northern hemisphere of Mars so smooth and flat, while the southern hemisphere is so cratered and rugged?

Polar Ice Caps

___ What are the ice caps on Mars made of?
___ How do the ice caps change throughout the martian year?
___ What are the dark lanes and other features seen on the martian ice caps?

Activity 1: Sample Science Goals (cont.)

Canyons
__ What formed the canyon systems on Mars?
__ Did water ever flow through the canyons?
__ Have the canyons been eroded by wind or water?

Channels and Gullies
__ What formed the channels we see on Mars?
__ What evidence is there of water flowing through the channels?
__ What is the source of any water that flowed through the channels?
__ Where did the water go?
__ How long ago did water flow on Mars and for how long did it flow?
__ Have the channels been eroded by wind or water?

Atmosphere
__ Why do the clouds we see in the atmosphere of Mars form?
__ What are the clouds in the atmosphere of Mars made of?
__ What do the cloud patterns tell us about the winds on Mars?
__ What do the patterns of sand dunes tell us about the winds on Mars?
__ How are global dust storms created?
__ How often do global dust storms occur and how long do they last?
__ What affect do dust storms have on the surface of Mars?

Dust and Sand
__ What is the dust on Mars made of?
__ How does the dust move around the planet throughout the martian year?
__ Where is it dusty and where is it rocky on Mars?
__ Are there microscopic lifeforms living in the soil on Mars?

Radiation and Magnetic Field
__ Did Mars ever have a planetary magnetic field? If so, what happened to it?
__ Are there any rocks on Mars that still have a magnetic field?
__ How much radiation reaches the surface of Mars?
__ Do the landforms on Mars provide any protection from radiation?

Your Own Questions

__ ____

__ ____

__ ____

__ ____

__ ____

Activity 2: Science Goals

In Activity 1 you classified a number of science goals according to NASA's "Follow the Water" strategy for the exploration of Mars. Your task for this activity is to select the science goals that you hope to achieve with your mission!

Using the list in Activity 1 (including the goals you created yourself), choose five science goals for your mission. After discussing them with your team, rank your five science goals from 1 to 5 in order of importance to your team (1 being the most important).

When your team has agreed upon the science goals for your mission, record your five science goals, in order of importance, in the space below. On the lines below each science goal, record your team's reasons for why each goal is important. Be sure to explain how your goals fit into NASA's "Follow the Water" strategy!

1) Goal: ______________________________

Reason: ______________________________

____

2) Goal: ______________________________

Reason: ______________________________

____

3) Goal: ______________________________

Reason: ______________________________

____

4) Goal: ______________________________

Reason: ______________________________

____

5) Goal: ______________________________

Reason: ______________________________

____

Our mission will be a ______________ (fly-by/orbiter/lander) mission.

Engineering Constraints

As mentioned earlier, engineering constraints are limits that are placed on your mission by the **hardware** – the rockets, the spacecraft, the science instruments, and other systems – you use to accomplish that mission. In this section you will look at some of these constraints.

A. Size and Mass: Some engineering constraints are due to the strength of the rocket booster you use to send your spacecraft to Mars. NASA would very much like to send every scientific instrument imaginable to Mars! Unfortunately the spacecraft would have to be so big that no rocket in existence could launch it into space. Engineering constraints often force you to make trade-offs. These constraints may keep you from being able to achieve all of your science goals, so you have to choose the hardware that will allow you to achieve as many of your science goals as possible.

B. Budget: The United States Congress sets the **budget**, the total amount of money available to spend, for each NASA mission. NASA must, therefore, design missions to achieve as many science goals as possible while still staying within the mission's budget. Bigger rocket boosters can carry bigger spacecraft, but unfortunately, they cost a lot more to launch.

C. Power: Every spacecraft needs power in order to function. The more instruments that are onboard, the more power is needed for them to operate. **Solar panels** produce electricity through a special material that interacts with sunlight. Solar panels must be very large, but even so, still do not produce a lot of power. Solar panels require a great deal of direct sunlight to operate, so missions with solar panels are limited to being near the equator and can only operate for about three months of the year. **Fuel cells** create power through a chemical reaction much like batteries and produce a moderate amount of power, but they will only function for a limited period of time, generally only a few days or weeks. **Radioisotope power systems** (usually called an **"RPS"**) produce power from the heat generated by decaying radioactive materials. RPS's produce a lot of power and can operate at any time of year, anywhere on the surface. They are, however, quite heavy, extremely expensive, and require more precautions to use.

D. Reliability: The last constraint you will have to consider is the reliability of the spacecraft and its booster. Some boosters are more reliable than others – are you willing to accept a greater risk to save money? You should think about how you would revise your mission if you were to lose some of your hardware in flight. Having backup systems on-board just may save your mission!

Activity 3: Engineering Contraints

In the previous activity you worked out the science goals you want to be met by your mission. In this activity you will begin to think about the limits that will be placed on your mission design: engineering constraints. Answer each question as completely as possible, discussing each with your teammates. Your list of engineering constraints, along with your list of science goals, make up your **design specifications document**. Your final mission design will be compared to your design specifications document to see how well it accomplishes your goals with the limitations that have been established. For this activity you will use a set of "equipment cards" which describes each piece of equipment, and lists its mass, power requirements, cost, and any special capabilities or restrictions it may have.

1. Booster Capabilities

Look through the equipment cards and find all of the rocket boosters (red-bordered cards) that you have available. Notice that they have no mass or power cost listed. That is because they generate their own power through their engines and are able to lift their own mass in addition to the mass of the spacecraft they carry. The description for each booster tells how much mass it can lift in addition to its own mass. Record this mass, the reliability rating, and the cost of each booster in the space below.

Booster Name	Mass Lifted	Reliability Rating	Cost
______________________	________	____________	_____
______________________	________	____________	_____
______________________	________	____________	_____
______________________	________	____________	_____
______________________	________	____________	_____

2. Budget

As you have learned, NASA's budget for each space mission is set by the United States Congress. In this case, your budget will be set by your teacher or facilitator. Record that maximum budget amount here (NOTE: The number next to the dollar sign on each card is the cost of that system in millions of dollars.):

Maximum Budget: $______________________________

Activity 3: Engineering Constraints (cont.)

3. Power

The power required by your spacecraft is the total power required by all its components combined. Each power source (orange-bordered cards) your spacecraft carries generates a certain amount of power that can be used by your other systems. The power sources themselves do not use power (except for the on-board battery, which stores power). The description of each power source lists how many units of power it generates, along with any special advantages or disavantages. Keep in mind that you do not have to limit yourself to only one kind of power source! Also, many power sources require a battery to store power. In the spaces below, list each power source, the amount of power it generates, its mass, and its cost.

Power Source	Power Generated	Mass	Cost

4. Safety

When designing your mission, you may have limitations placed on you by a landing site or by hazardous materials that might be on board during launch. You also need to plan for possible hardware failures during the mission. Work out a plan with your teammates for dealing with these issues and record it in the space below.

Activity 4: Building Your Spacecraft

Your team has decided on its science goals and has also looked at the engineering constraints that will limit your mission. It's now time to build the spacecraft you will use to accomplish your mission. Use the "equipment cards" included with this activity to help design your spacecraft. You are to work with your team to design your spacecraft by assembling the cards that represent each system involved in your mission. Read each card carefully to make sure you have all the required systems on board your spacecraft. Remember, your objective in this activity is to design a spacecraft that will stay under budget, be launchable with existing rocket boosters, and meet all of your science goals within the engineering constraints you have identified. Here are some things to keep in mind:

- Make certain that your booster can lift the mass of the spacecraft!
- Make sure you have enough power to run all of the systems onboard.
- Do you have the instruments you need to fulfill your science goals?
- How safe is your spacecraft? Will you need special care during launch?
- Do you have backups for your most critical systems – you may lose them in flight!
- Make certain you stay within your budget!

Keep in mind that the design process is a loop: You may have to go back and change your science goals, look at your constraints again, and change your design. This is all part of the process. In the end, you should have a mission design that is a good balance between meeting your science goals and satisfying your engineering constraints.

When you have completed your design, record it on the Spacecraft Design Log on the next page. Your teacher or facilitator may have other instructions for you to follow as well. Take careful notes during your discussions while designing your spacecraft – they will help you when the time comes to submit your final report to NASA!

Activity 4: Building Your Spacecraft (cont.)

Spacecraft Design Log

Spacecraft Component	Mass	Power	Cost

Totals ________ ________ ________

Activity 5: The Design Specifications Document

Now that you have developed your mission to the Red Planet, the only task remaining for you to do is to write up your mission design and send it to NASA! You have already done everything you need to write your design specifications document, you just need to tie it all together into one, organized paper. Your report should follow the outline shown below:

I. Introduction
Include your team name, where your team is from, the name of your school or organization, your grade or age, and your teacher or adult facilitator's name. Write a couple of sentences explaining why your mission is important for NASA to consider.

II. Science Goals
Write a brief paragraph explaining each of your science goals, why you chose them, how they fit into NASA's overall plan for Mars exploration, and how they fit together for your mission. Can you think of any spin-offs that might come from your mission?

III. Engineering Constraints
What engineering constraints does your mission face? How will your mission handle safety issues, hardware failures, or other problems?

IV. Spacecraft Design
Describe each of the components and instruments that make up your spacecraft. Why did you choose each component? How will they help you achieve your science goals? Were you under budget? If so, by how much?

V. Conclusion
Summarize the most important points about your mission and why you feel NASA should consider it for flight.

Remember, you should write an original organized paper, not just submit the activity worksheets you used to design your mission. When you are ready to submit your design, go to the Marsbound! website at http://marsbound.asu.edu and cut-and-paste your report into our online form. If accepted, your team will appear in our roster of Certified Student Mission Planners!