A Dynamic Digital Map of Mars

Selby Cull
Hampshire College

Advisor: Christopher Condit
University of Massachusetts, Amherst

Abstract

A Dynamic Digital Map of Mars was produced, incorporating 682 images, 185 maps, over 85 pages of captions, and over 80 pages of articles on Mars. The DDM-Mars also incorporates interactive features such as tours, exercises, and map overlays that allow users to tour different aspects of Mars, its science, and the history of our understanding of it.

Introduction

"Data, data everywhere, but not a thought to think." ~ Jesse Shera

Facts and figures are relatively easy to come by. A simple Google or SciFinder search turns up more articles, images, and ideas than one will ever be able to sort through. For science students, looking up background information can be frustrating, time-consuming, and non-productive.

For students studying Mars, the problem is exacerbated by the vast amount of information available online, in journals, and in books. The rovers and satellites studying Mars right now send back huge amounts of data every day, much of which is indexed online.

This paper describes the initial results of a two-year project to create a Dynamic Digital Map of Mars (DDM-Mars). The purpose of the DDM-Mars is to integrate many different types of data with articles and interactive tools that allow students to explore Mars science with ease.

Dynamic Digital Maps

A Dynamic Digital Map (DDM) is an interactive software program that incorporates maps, images, movies, data, articles, interviews, animations, and class activities (Condit 1999; Condit and Boundy 2002; Condit 2000). DDMs are designed to serve many purposes, including teaching tools and data presentation. For a more detailed description on using DDMs interactively in large geology classes, see Condit (2001).

DDMs are designed to run on most computer platforms, including Macintosh OS 9 and OS X, Windows, Linux, and Unix variations. The software can be downloaded for free off the internet at http://ddm.geo.umass.edu. DDMs currently available include DDM-New England, DDM-Springerville Volcanic Field, DDM-Tatara-San Pedro Volcanic Complex in Chile, DDM-Moon, DDM-Holtwood PA, DDM-David Mine, and DDM-Mars.

Methods & Materials

The DDM-Mars was created using Runtime's Revolution program, a relative of the older SuperCard and HyperCard applications. Though the basic coding for the program was based on Christopher Condit's DDM-Template, a project funded by the National Science Foundation, the majority of the coding was built from scratch.

Maps

The Mars globe as divided into 37 major regions (Table 1). Five types of maps were obtained for each region:

- Viking mosaics on a cylindrical projection
- Viking mosaics on a sinusoidal projection
- Geologic maps from the NASA Lab for Terrestrial Physics Geodynamics Branch
- Thermal inertia maps from the Mars Global Surveyor Thermal Emission Spectrometer (TES)
- Topographic maps from the Mars Global Surveyor Mars Orbiting Laser Altimeter (MOLA).

Table 1: Regions

Acidalia Planitia	Planum Australe
Alba Patera	Planum Boreum
Amazonis Planitia	Promethei Terra
Aonia Terra	Sinai Planum
Arabia Terra	Solis Planum
Arcadia Planitia	Syria Planum
Argyre Basin	Syrtis Major Planum
Chryse Planitia	Tempe Terra
Daedalia Planum	Terra Cimmeria
Elysium Planitia	Terra Meridiani
Ganges Chasma	Terra Sabaea
Gusev Crater	Terra Sirenum
Hellas Planitia	Tharsis Montes
Hesperia Planum	Tyrrhena Terra
Isidis Planitia	Utopia Planitia
Lunae Planum	Valles Marineris
Margaritifer Terra	Vastitas Borealis
Noachis Terra	Xanthe Terra
Olympus Mons	

A total of 185 maps were assembled and integrated into the DDM-Mars.

Images

Images of Mars, its regions, its features, and related topics were assembled from various sources. These included: images of major geologic features for each of the 37 regions, images from each of the successful missions to Mars, and images of minerals, meteorites, volcanoes, and water-related feature.

Most of the images are from:

- Mars Orbiter Camera (MOC)
- Thermal Emission Imaging Spectrometer (THEMIS)
- Thermal Emission Spectrometer (TES)
- Mars Express High-Resolution Stereo Camera (HRSC)
- Viking 1 and 2 orbiters
- Viking 1 and 2 landers
- Phobos 2 satellite
- Mariners 4, 6, 7, and 9

- Pathfinder rover
- Spirit and Opportunity rovers

To date, 682 images have been added to the project.

Articles

Three types of articles were written for the project:

- **Reference Articles:** These basic fact sheets were compiled for each region and volcano on Mars, each Mars meteorite, and each significant mineral featured in the program. A total of 109 reference articles were written.

- **Science Overviews:** For major missions or topics, short articles summarizing the basic science were written. These were composed at an undergraduate level, aimed at undergraduate geology majors. A total of 30 science overviews were written.

- **General Audience Overviews:** Broad topics of interest to students and the general public alike were examined in longer articles. These topics include the hunt for minerals on Mars, histories of the early Mars missions, the challenges of sending humans to Mars, evidence for an ancient ocean on Mars, and how extreme life forms on Earth might shed light on the Mars life problems. A total of 10 of these longer articles were written.

Currently, there are over 80 pages worth of articles incorporated into the DDM-Mars, all aimed at an audience of undergraduate geology majors.

Interactive Features

Several interactive features were built into the program, including:

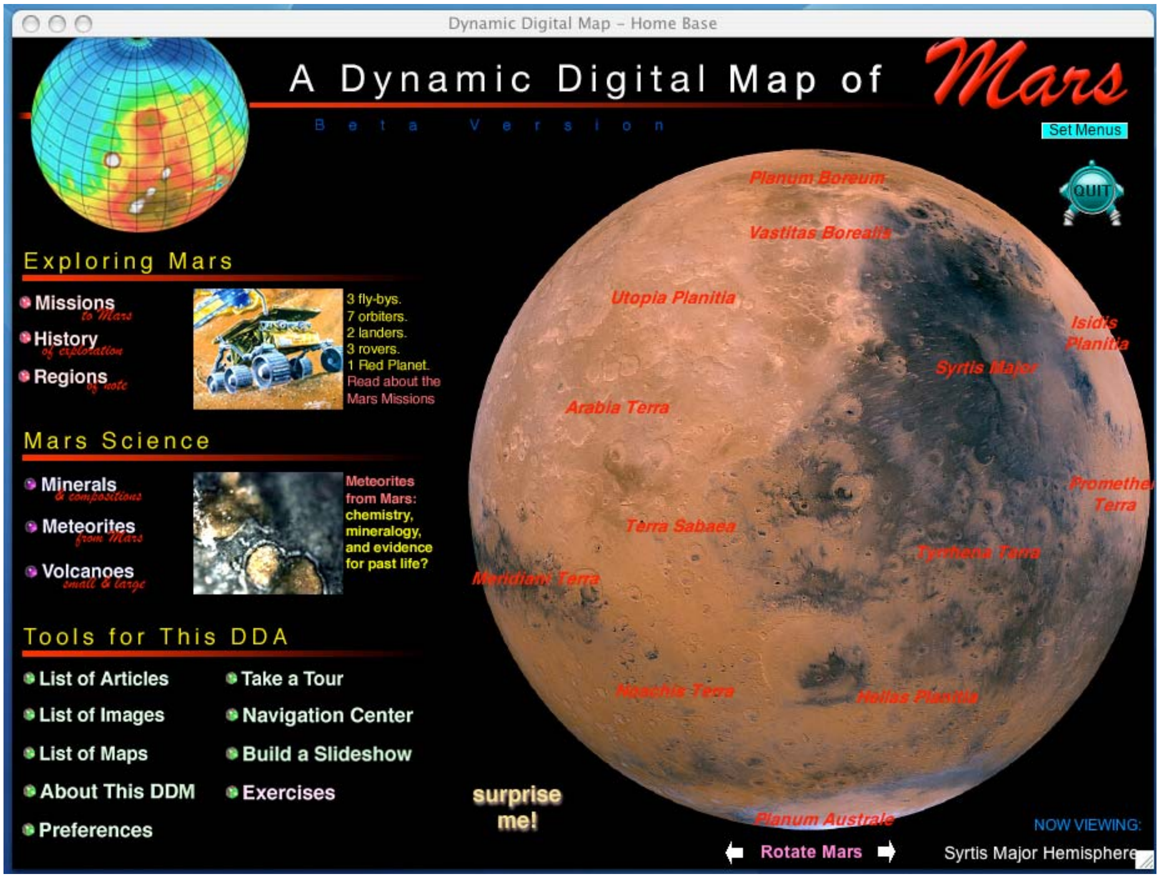
- **Tours:** Tours of topics in Mars science were written, designed, and built, including a tour of Martian geography and of the hunt for minerals on the Martian surface.

- **Exercises:** Exercises designed for lab classes were written, designed, and built. These were designed to illustrate different methods of thinking about Mars. For example, one exercise gives students information about a fictional mineral, then asks them to determine where on Mars such a mineral might be found, based on images, spectral data, and topographic profiles. Another exercise asks students to design a human mission to Mars, then launches the mission they designed to see how well they designed it.

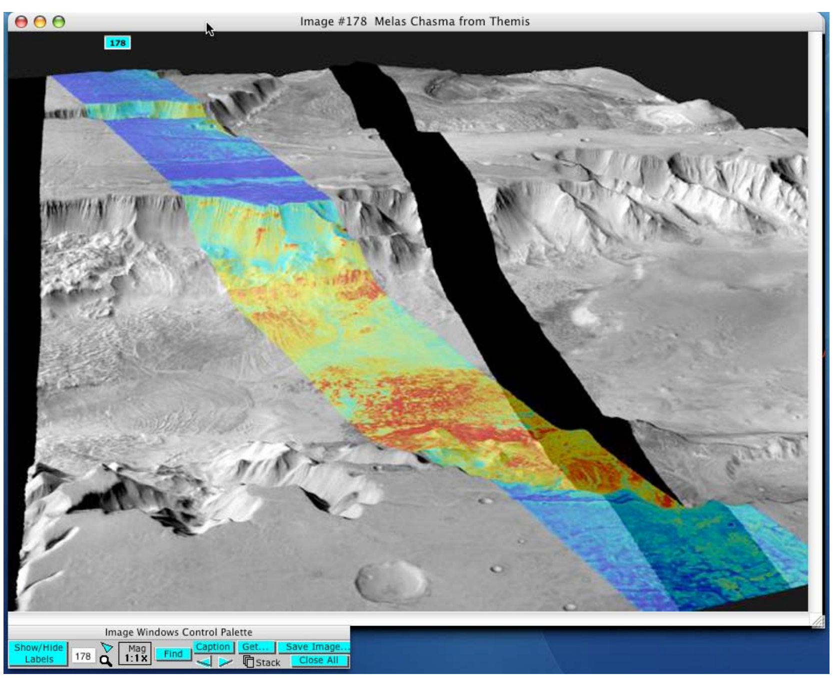
- **Build a Slideshow:** One feature allows users to assemble a slideshow of their favorite Mars images, adding caption data and saving them.

Results

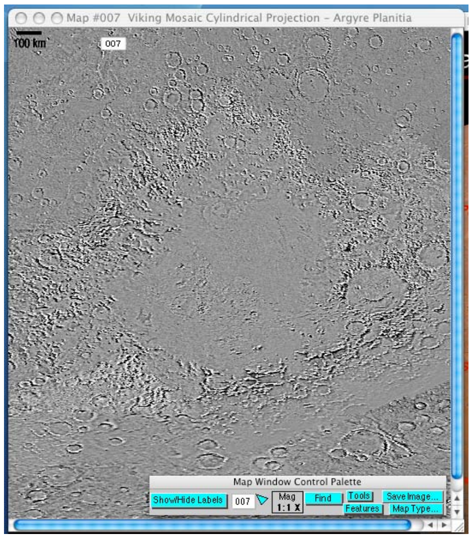
The results are presented both in screenshots below, and in the accompanying CD-ROM.

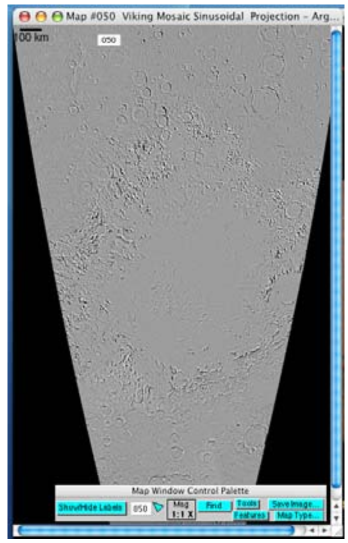


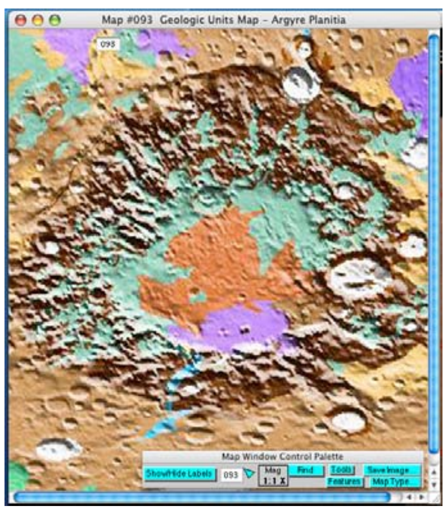
The Home Page: From this page, the user can access any part of the program.

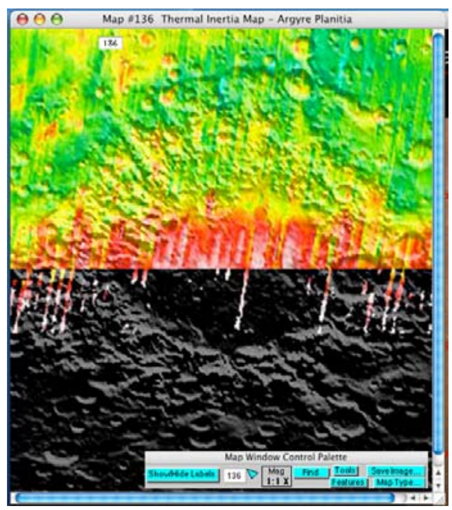


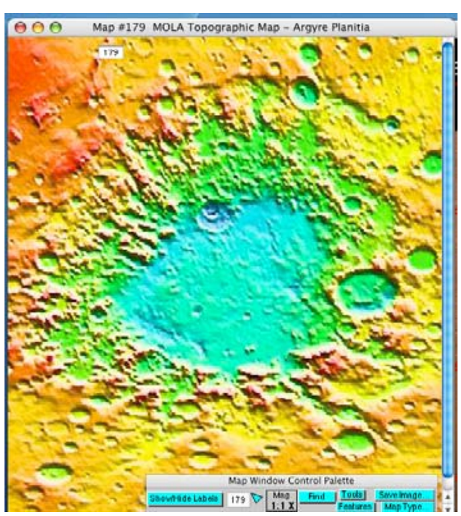
The basic materials making up the DDM-Mars are the images (left), maps, and articles. See below.







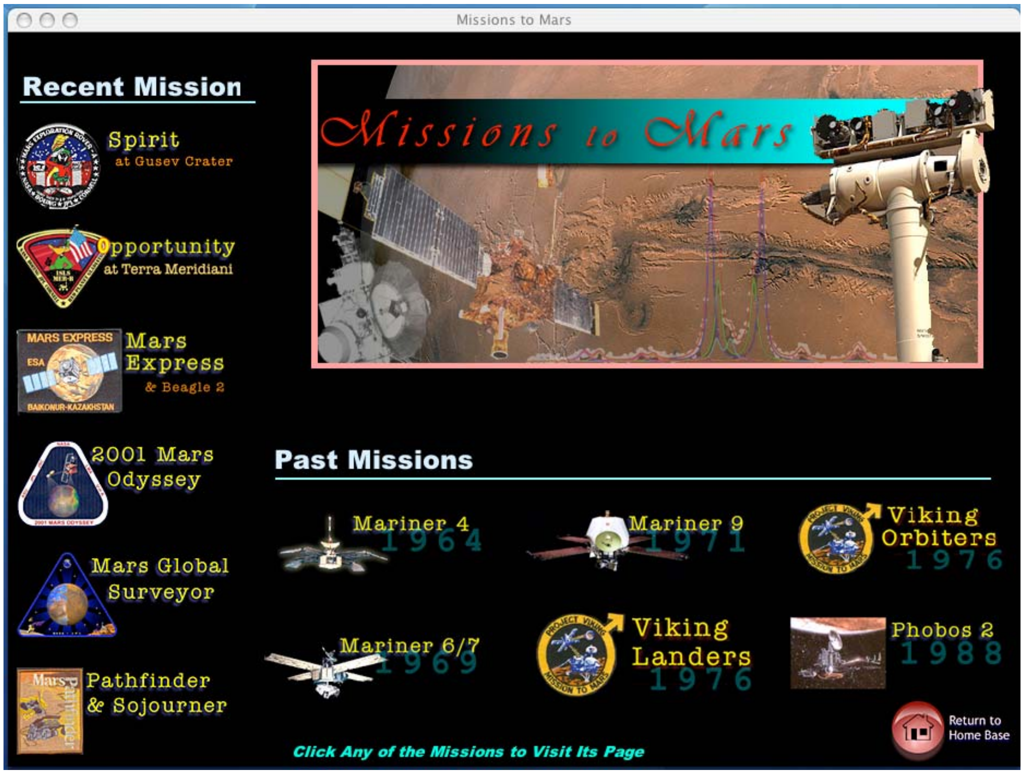




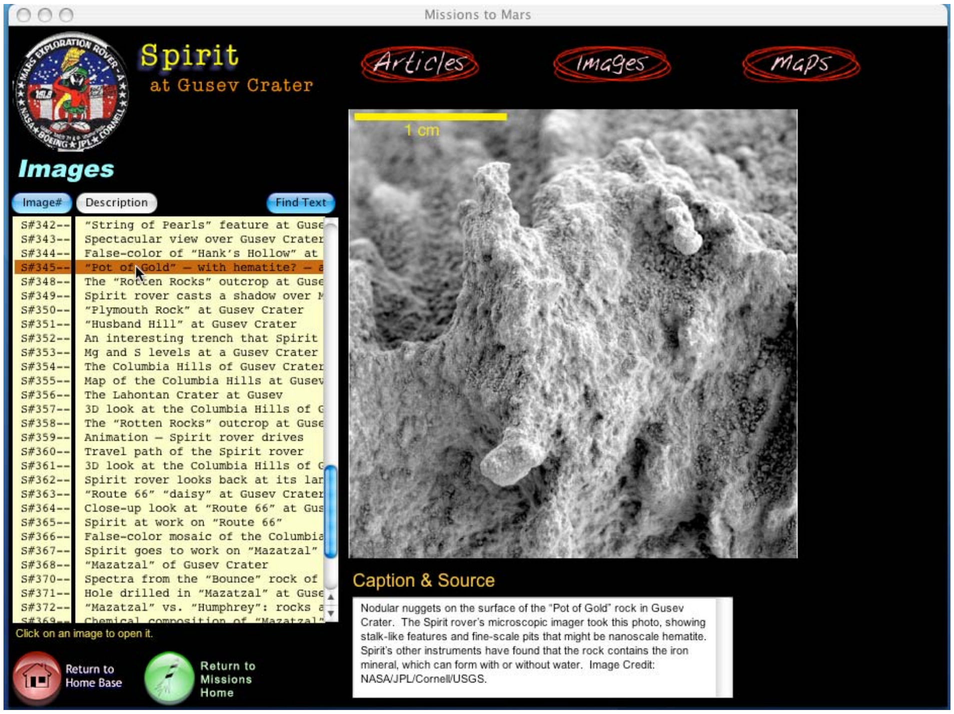
The five map types for Argyre Basin in the southern hemisphere of Mars. From left to right: top: Viking mosaic cynlindrical projection, Viking mosaic sinusoidal projection. Middle: Geologic units map, thermal inertia map. Bottom: MOLA topographic map.

Part I: Exploring Mars

The first part of the DDM focuses on our exploration of Mars by examining the different missions that have visited the planet ("Missions"), stories of our discoveries ("History"), and the different regions we have identified and studied ("Regions"). See below.

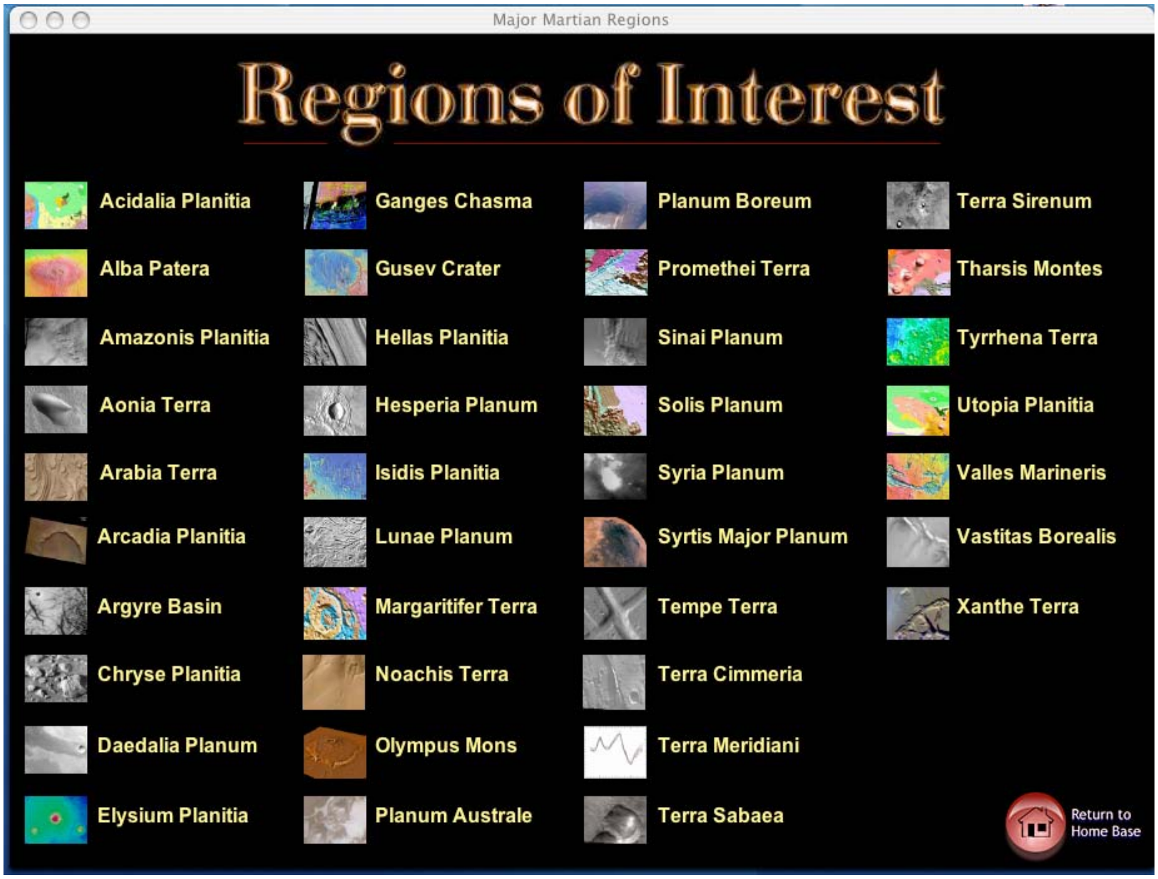


Missions: The Mission section of the DDM details the 12 successful missions to Mars. Each mission page features images and figures related to the mission (below top), articles on the mission (below bottom), and maps produced by the mission.

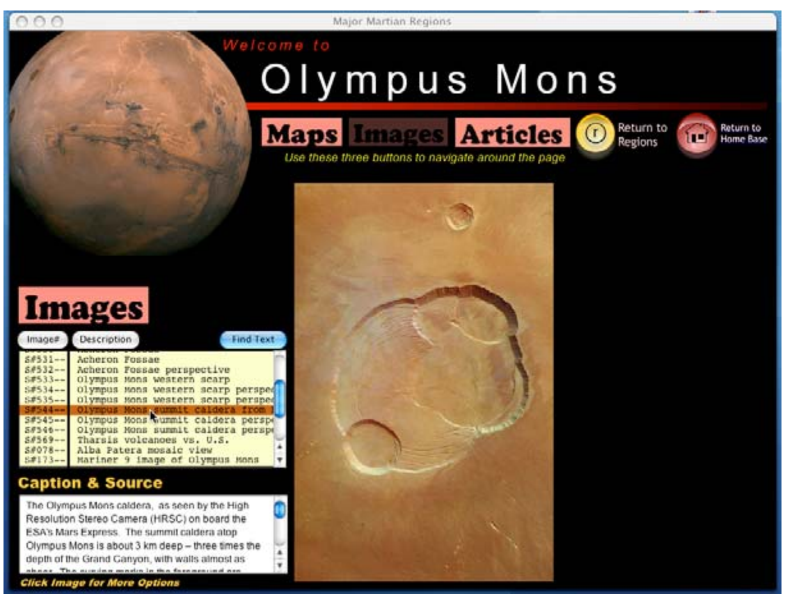

Missions to Mars
Spirit
at Gusev Crater
Articles
Images
Maps
Images
Image#
Description
Find Text
S#342-- "String of Pearls" feature at Guse
S#343-- Spectacular view over Gusev Crater
S#344-- False-color of "Hank's Hollow" at
S#345-- "Pot of Gold" — with hematite?
S#348-- The "Rotten Rocks" outcrop at Guse
S#349-- Spirit rover casts a shadow over
S#350-- "Plymouth Rock" at Gusev Crater
S#351-- "Husband Hill" at Gusev Crater
S#352-- An interesting trench that Spirit
S#353-- Mg and S levels at a Gusev Crater
S#354-- The Columbia Hills of Gusev Crater
S#355-- Map of the Columbia Hills at Gusev
S#356-- The Lahontan Crater at Gusev
S#357-- 3D look at the Columbia Hills of
S#358-- The "Rotten Rocks" outcrop at Guse
S#359-- Animation — Spirit rover drives
S#360-- Travel path of the Spirit rover
S#361-- 3D look at the Columbia Hills of
S#362-- Spirit rover looks back at its la
S#363-- "Route 66" "daisy" at Gusev Crater
S#364-- Close-up look at "Route 66" at Gus
S#365-- Spirit at work on "Route 66"
S#366-- False-color mosaic of the Columbia
S#367-- Spirit goes to work on "Mazatzal"
S#368-- "Mazatzal" of Gusev Crater
S#370-- Spectra from the "Bounce" rock of
S#371-- Hole drilled in "Mazatzal" at Guse
S#372-- "Mazatzal" vs. "Humphrey": rocks
Click on an image to open it.
Return to Home Base
Return to Missions Home
1 cm
Caption & Source
Nodular nuggets on the surface of the "Pot of Gold" rock in Gusev Crater. The Spirit rover's microscopic imager took this photo, showing stalk-like features and fine-scale pits that might be nanoscale hematite. Spirit's other instruments have found that the rock contains the iron mineral, which can form with or without water. Image Credit: NASA/JPL/Cornell/USGS.

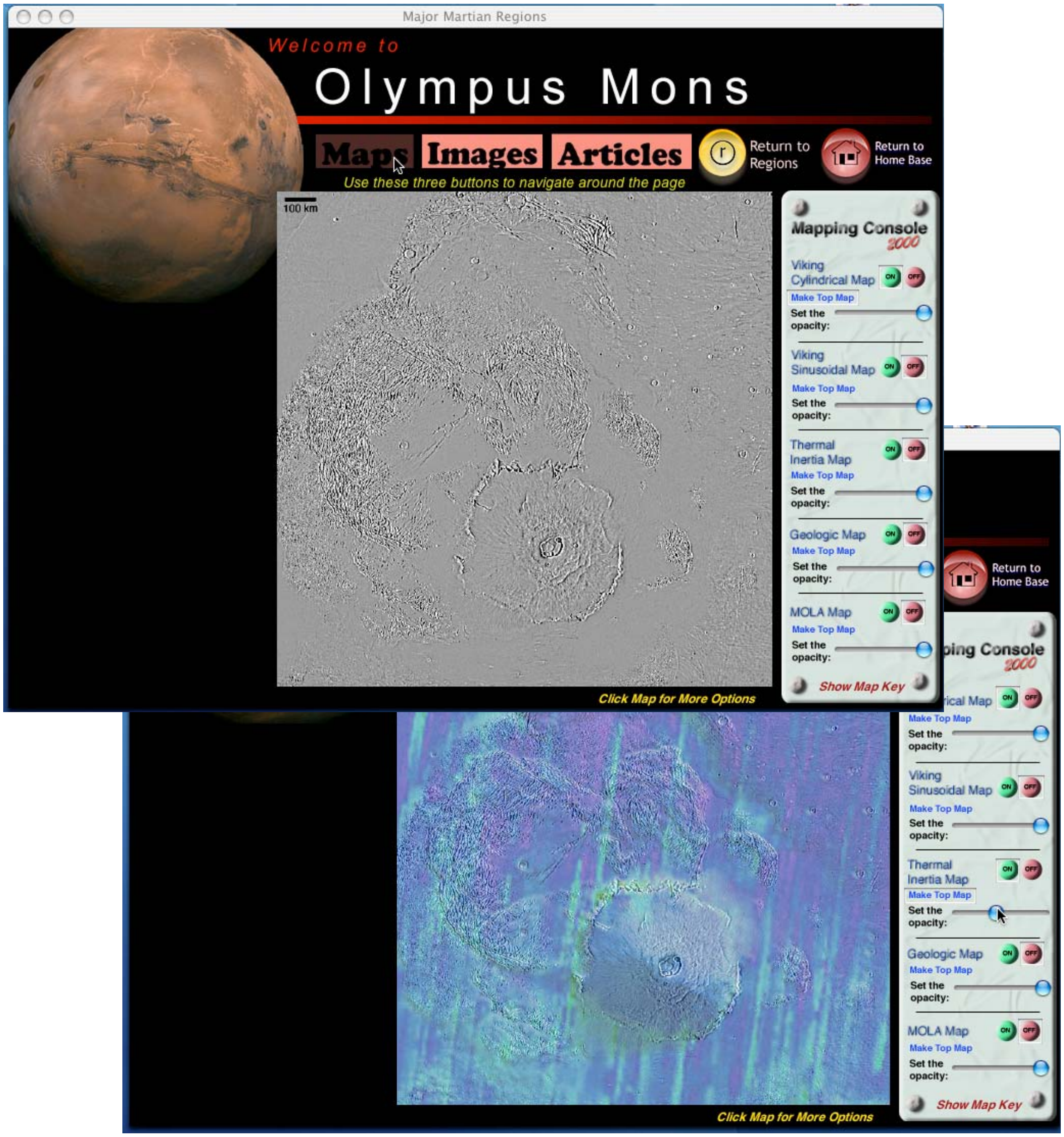

Missions to Mars
Spirit
at Gusev Crater
Articles
Images
Maps
Articles
Spirit & Opportunity: Basic Information
The Student Mars Rover Program
Return to Home Base
Return to Missions Home
Flatbread and Ice Cream Sandwiches: Student Involvement in the 2004 Mars Rovers
Copyright 2004 by Selby Cull and the Journal of Young Investigators. Re-printed with Permission.
A group of high school students has been lending NASA a hand with its two newest Mars rovers. Since January 2004, dozens of students from across the country have been jetting around Mission Control in California, setting up databases, anayzing data, processing information, naming rocks, and having the time of their lives.
The students are part of the Athena Student Intern Program (ASIP), a program sponsored by NASA and Cornell University, that has afforded 39 lucky high school students the opportunity to virtually explore Mars. Through ASIP, three high school students and one of their teachers are matched with a member of the Athena Payload Science Team (which runs the Mars Rovers). The students help the scientist process data, investigate inter-esting photographs, handle the press, and do some of the basic science needed to operate the rovers.
The program is NASAs latestand possibly most excitingini-tiative to excite the next generation about space.
The Student Teams
Teams were selected in early 2003 from applicants across the country, and came from high schools in Alabama, California, Colorado, Illinois, Nevada, New Mexico, New York, North Carolina, Pennsylvania, and Texas. For the mission, each team performed a unique and necessary task for the Mars Rover science teams.
Spirit and Opportunity, the 2004-2005 Mars rovers. Image Courtesy of NASA.
Spirit landing site in Gusev Crater, as seen by the Mars Express satellite.

History: This page presents the history of our exploration of Mars as a timeline. Users can click on the timeline to read longer articles about the topics (see below).



Regions: The Regions page features 37 regions (see Table 1 above). Each page in this sections features images (below) and articles related to the region, as well as an interactive map feature (see below).



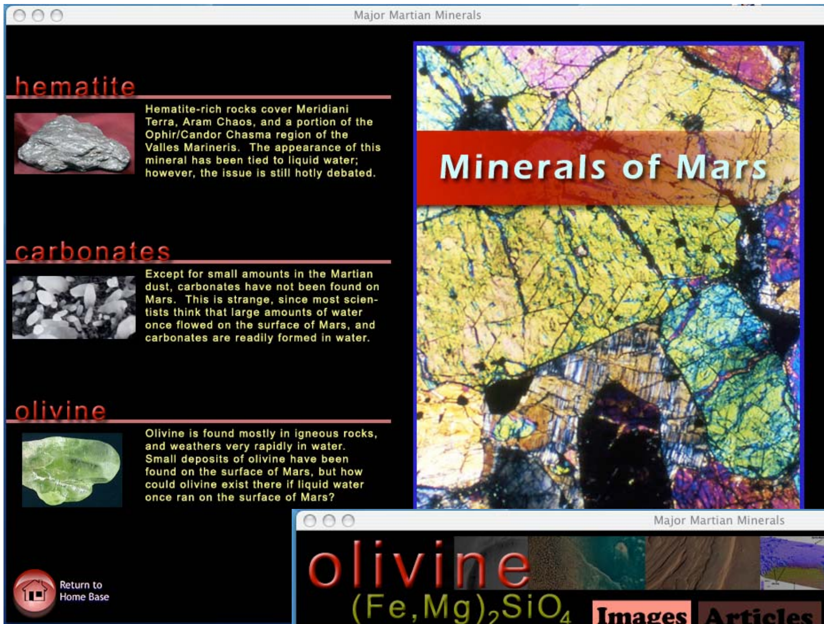


Regions: The interactive map function for the regions pages allows users to overlay different maps on each other. In the example above, a thermal inertia map of Olympus Mons is laid on top of a Viking mosaic to illustrate variations in thermal inertia with albedo.

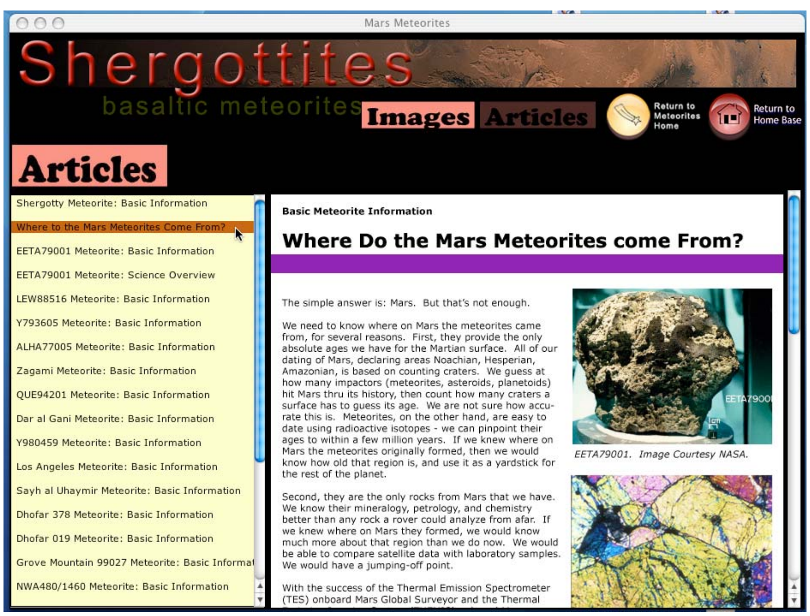
Part II: Mars Science

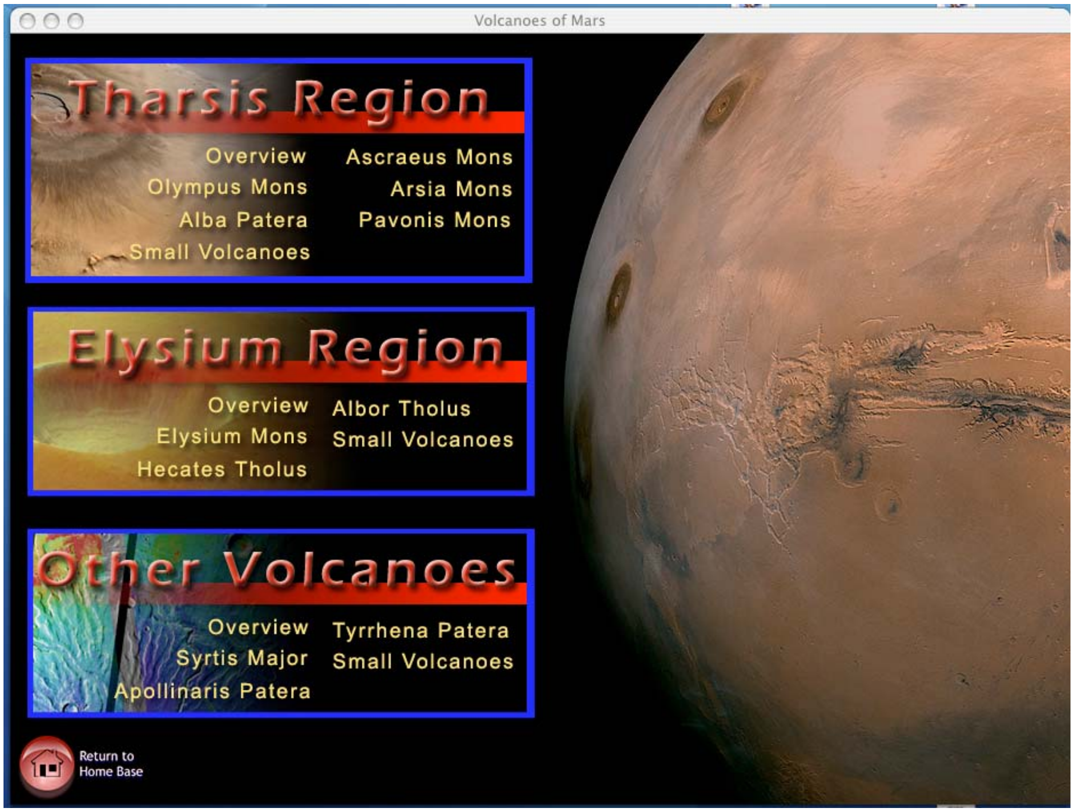
The second part of the DDM looks at different topics in Mars science, including Mars meteorites, minerals of Mars, and volcanism.

Minerals: The minerals pages look into what we know about hematite, olivine, and carbonates on the surface of Mars, using images, articles, and maps.

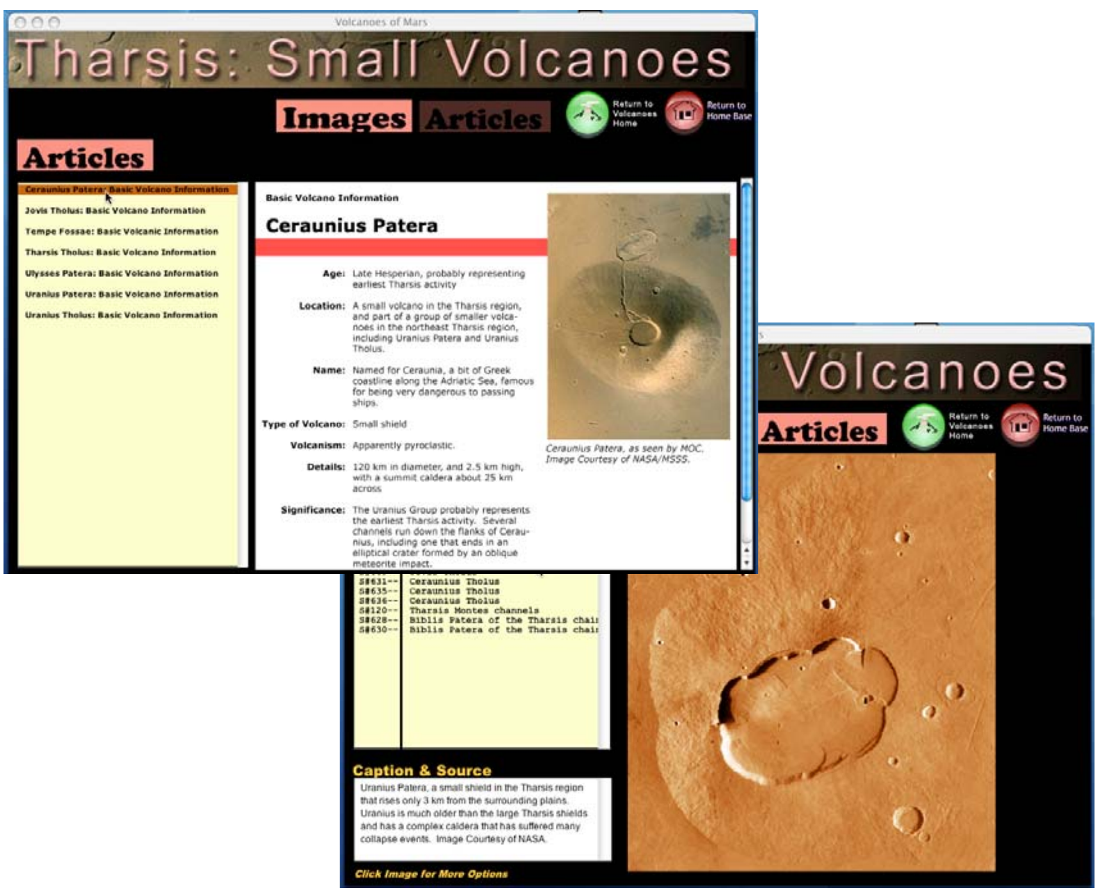


Meteorites: The Meteorite pages look at the SNCs: Shergotties, Nakhlites, and Chassignites.



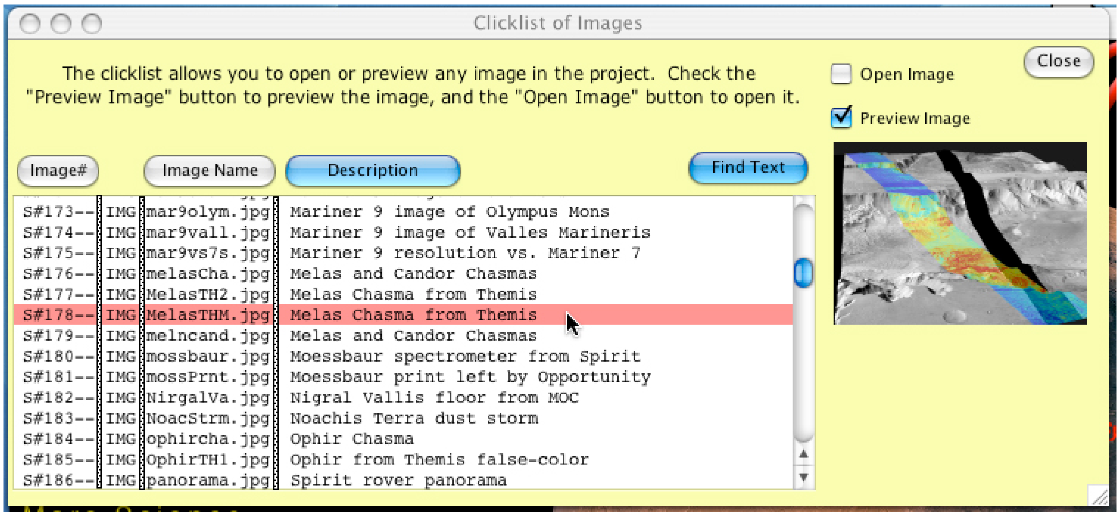


Volcanoes: The volcanoes pages feature articles and images of 14 major volcanoes on Mars.

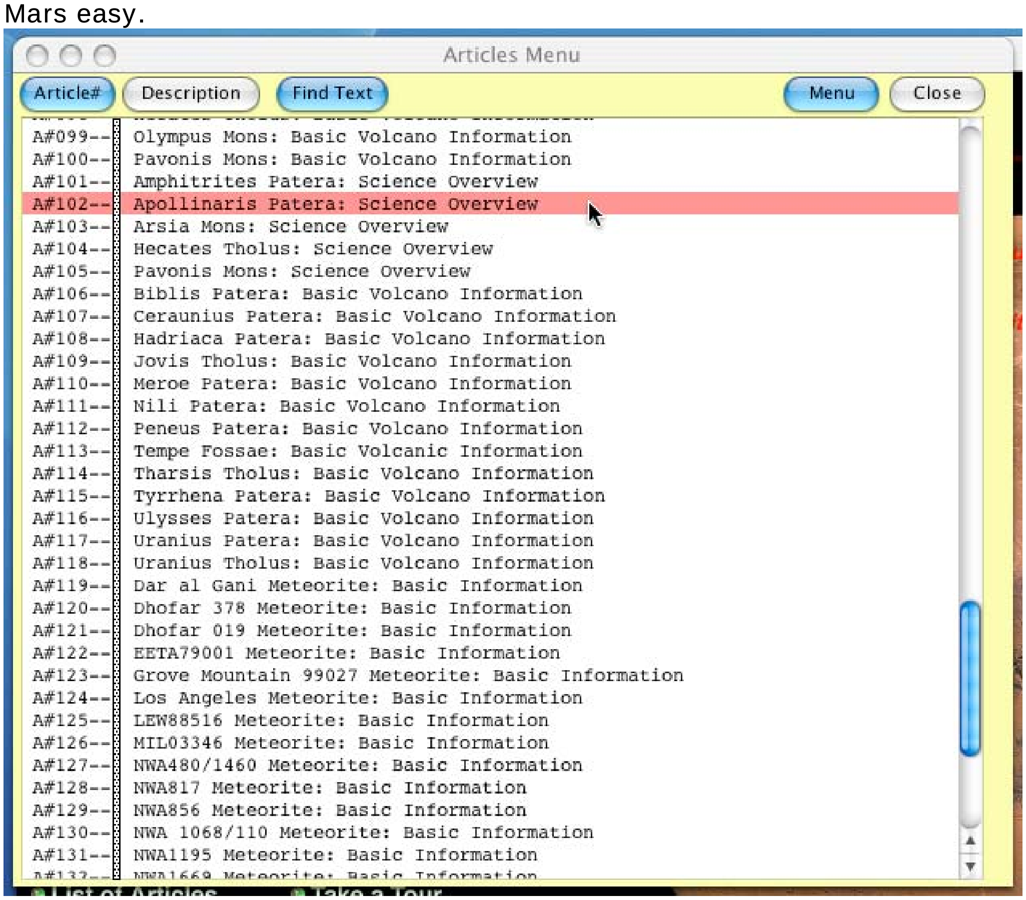


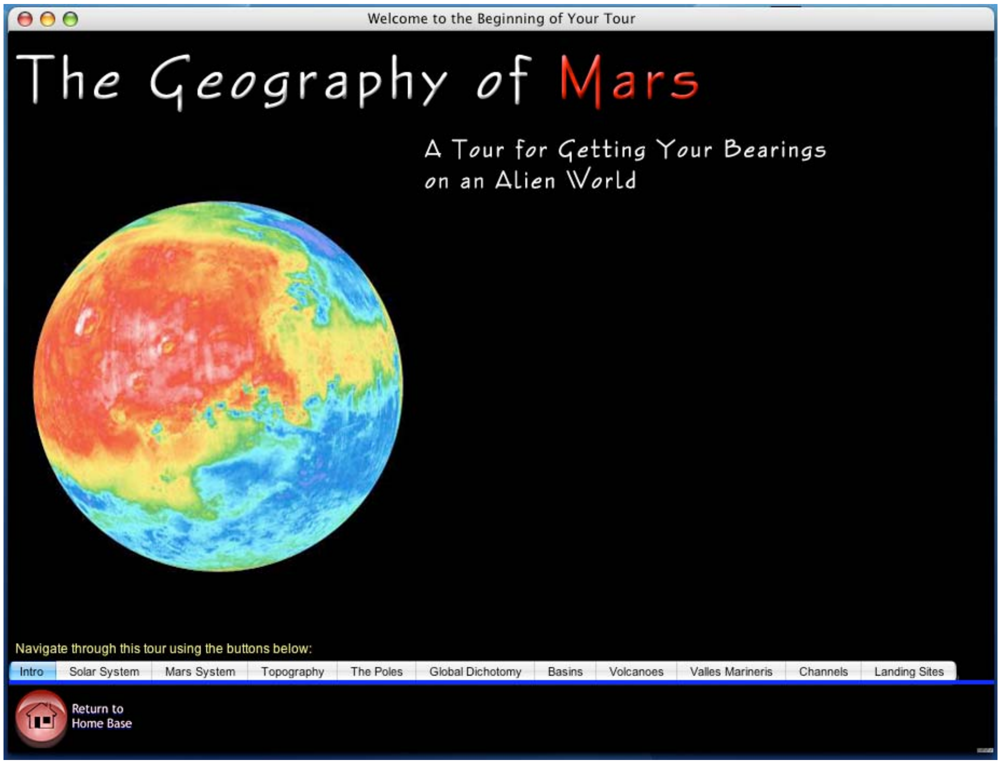
Part III: Interactive Tools

In addition to maps, images, and articles, the DDM-Mars includes serveral interactive features to help navigate through all the data.

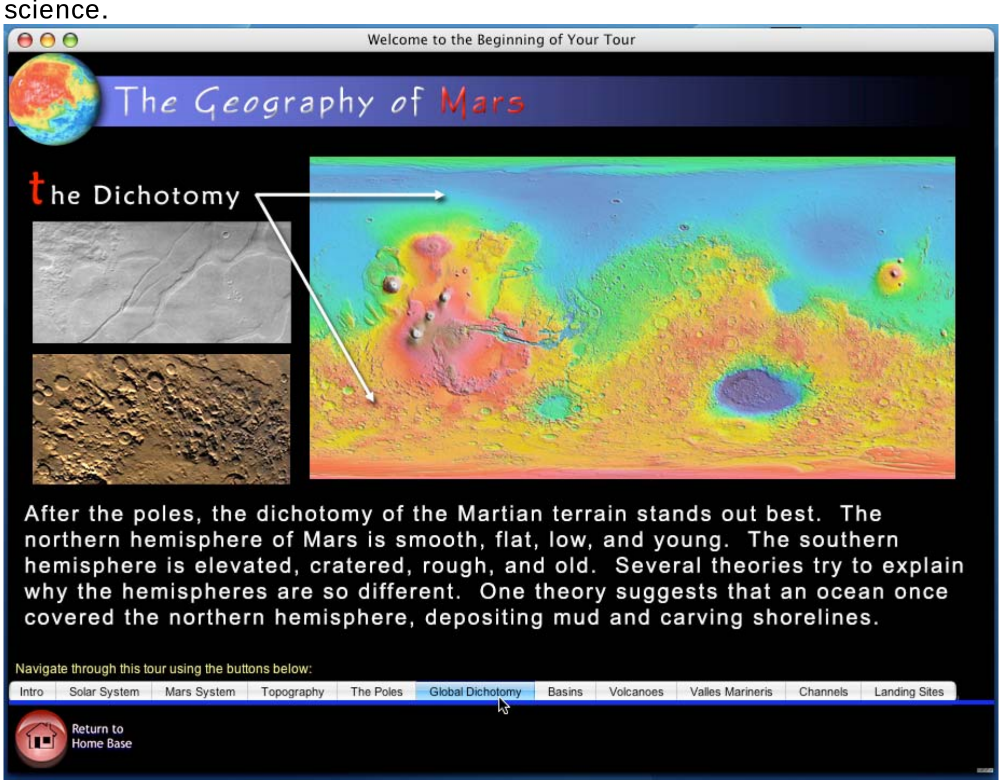


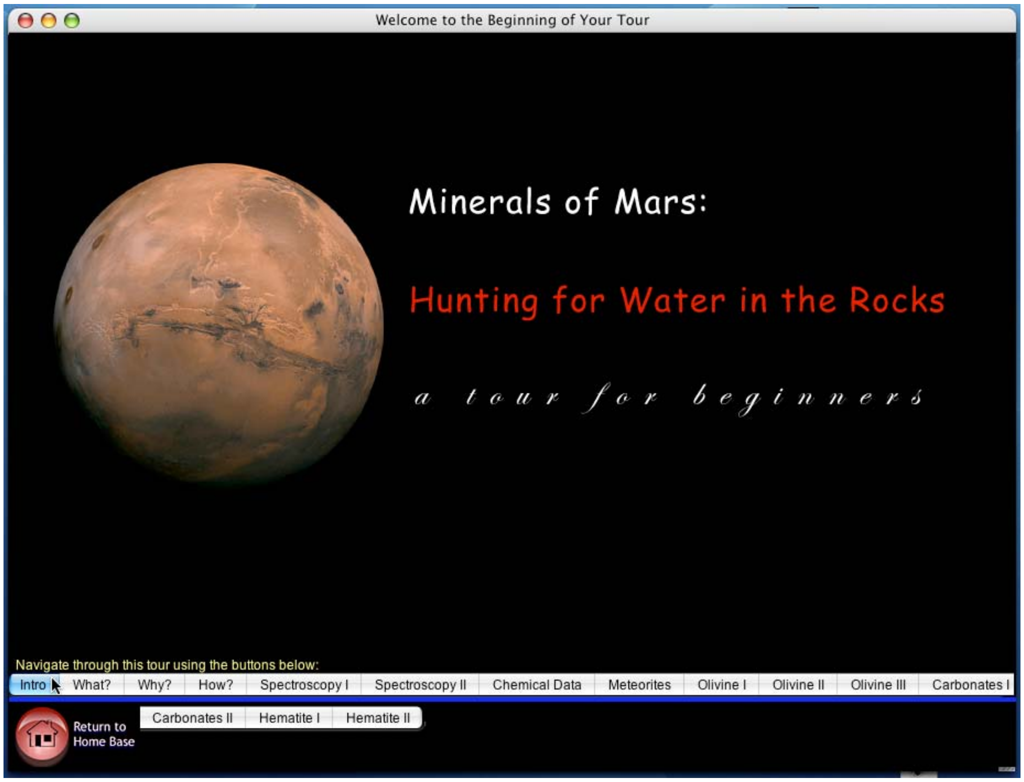
Cliklists: Clicklists of maps, images, and articles, make finding material in the DDM-Mars easy.

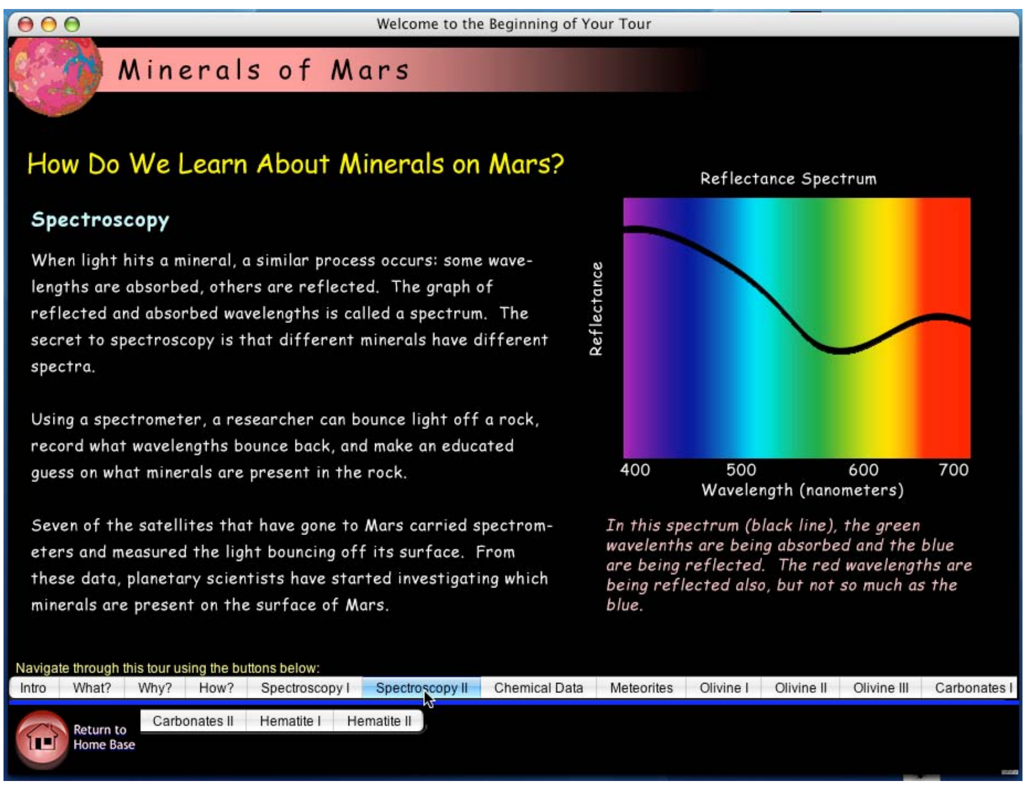


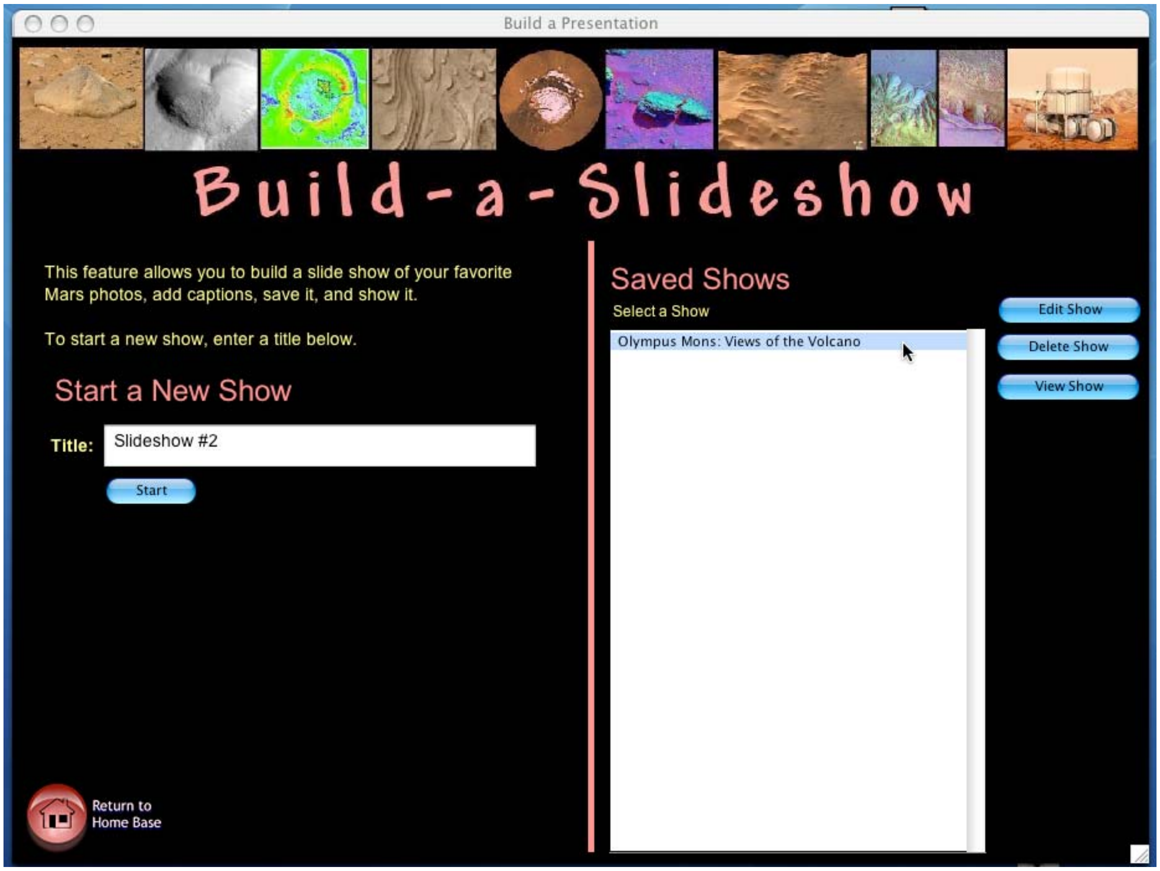


Tours: Interactive, self-guided tours lead students through various issues in Mars science.

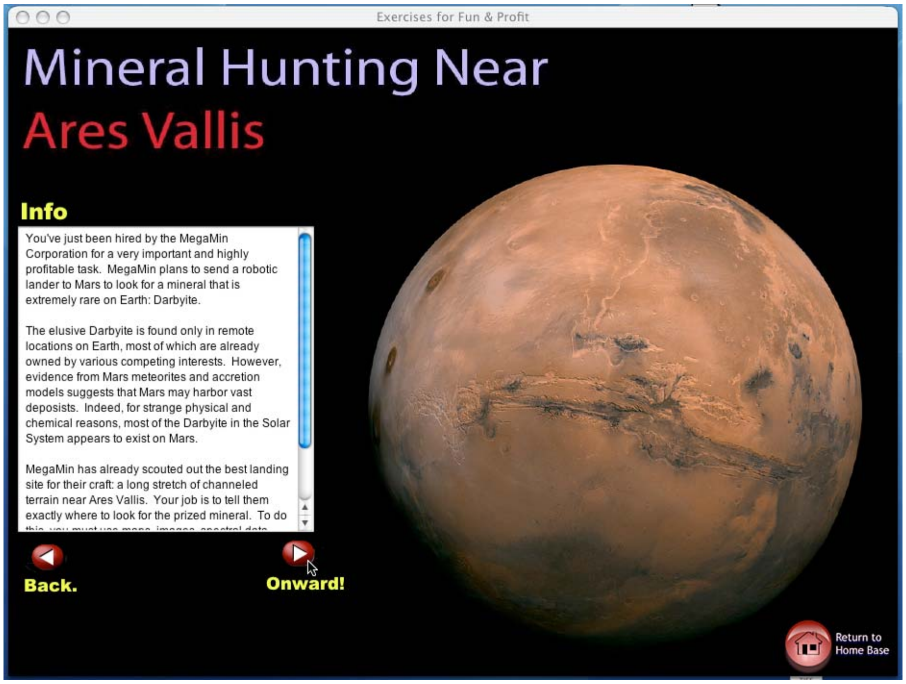



Welcome to the Beginning of Your Tour
Minerals of Mars:
Hunting for Water in the Rocks
a tour for beginners
Navigate through this tour using the buttons below:
Intro What? Why? How? Spectroscopy I Spectroscopy II Chemical Data Meteorites Olivine I Olivine II Olivine III Carbonates I
Carbonates II Hematite I Hematite II
Return to Home Base

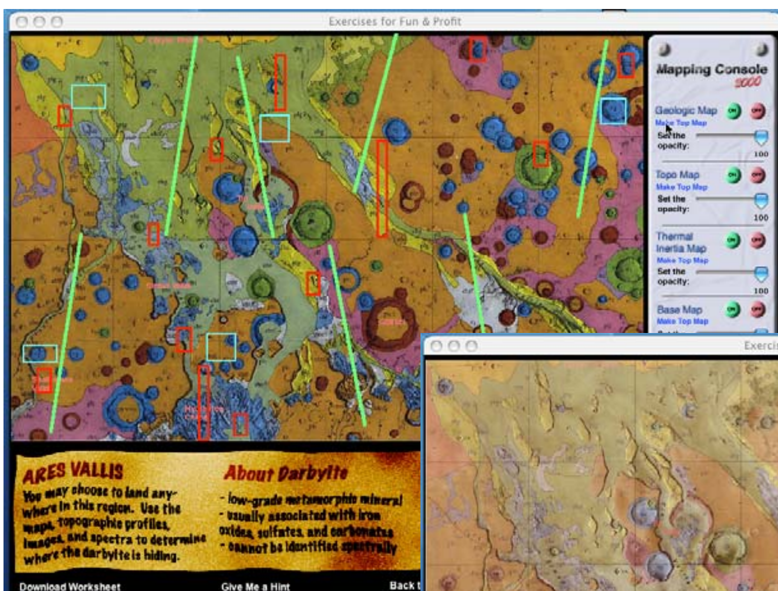

Welcome to the Beginning of Your Tour
Minerals of Mars
How Do We Learn About Minerals on Mars?
Spectroscopy
When light hits a mineral, a similar process occurs: some wave-lengths are absorbed, others are reflected. The graph of reflected and absorbed wavelengths is called a spectrum. The secret to spectroscopy is that different minerals have different spectra.
Using a spectrometer, a researcher can bounce light off a rock, record what wavelengths bounce back, and make an educated guess on what minerals are present in the rock.
Seven of the satellites that have gone to Mars carried spectrom-eters and measured the light bouncing off its surface. From these data, planetary scientists have started investigating which minerals are present on the surface of Mars.
Reflectance Spectrum
Reflectance
400
500
600
700
Wavelength (nanometers)
In this spectrum (black line), the green wavelenths are being absorbed and the blue are being reflected. The red wavelengths are being reflected also, but not so much as the blue.
Navigate through this tour using the buttons below:
Intro What? Why? How? Spectroscopy I Spectroscopy II Chemical Data Meteorites Olivine I Olivine II Olivine III Carbonates I
Carbonates II Hematite I Hematite II
Return to Home Base



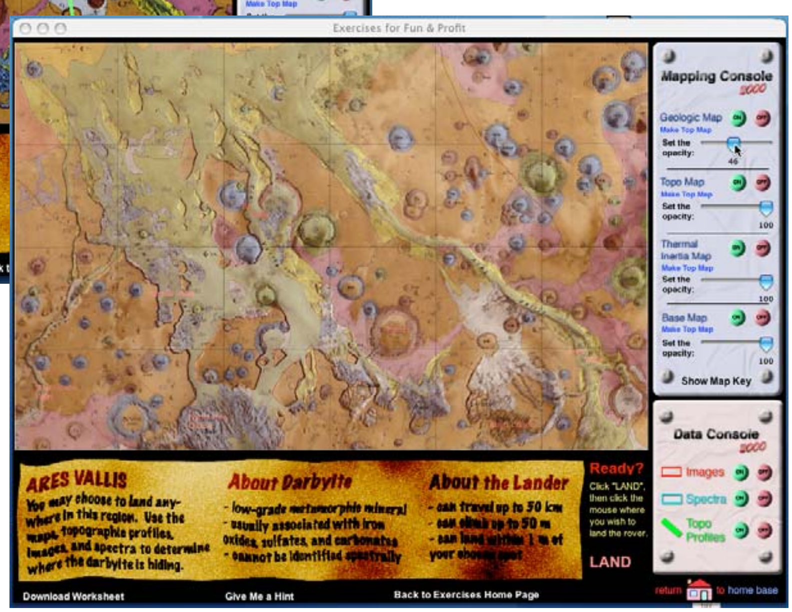
Slideshow: The Build-a-Slideshow feature allows users to build presentations of their favorite images and present them.

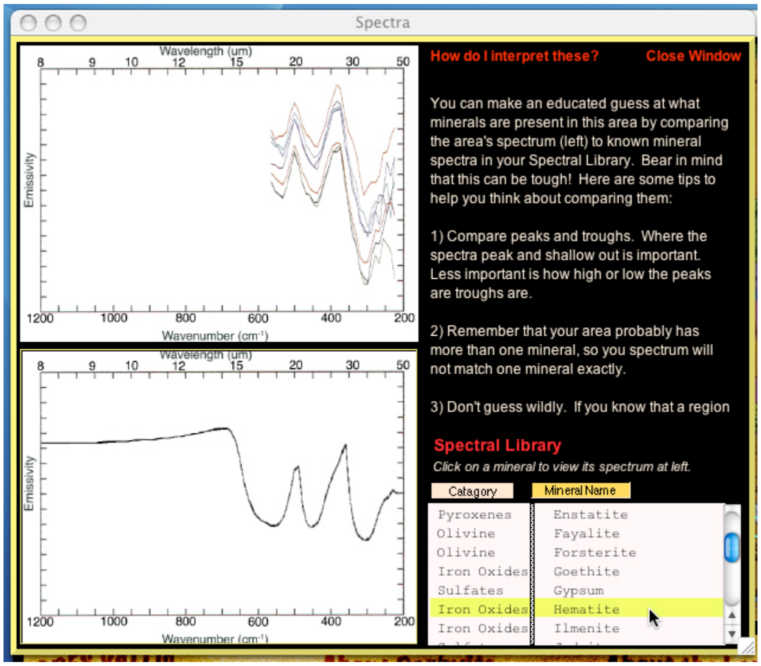


Exercises: The mineral hunting exercise gives users information about a fictious mineral, then asks them to find that mineral on Mars, using images, spectral data, and topographic profiles. (See below).



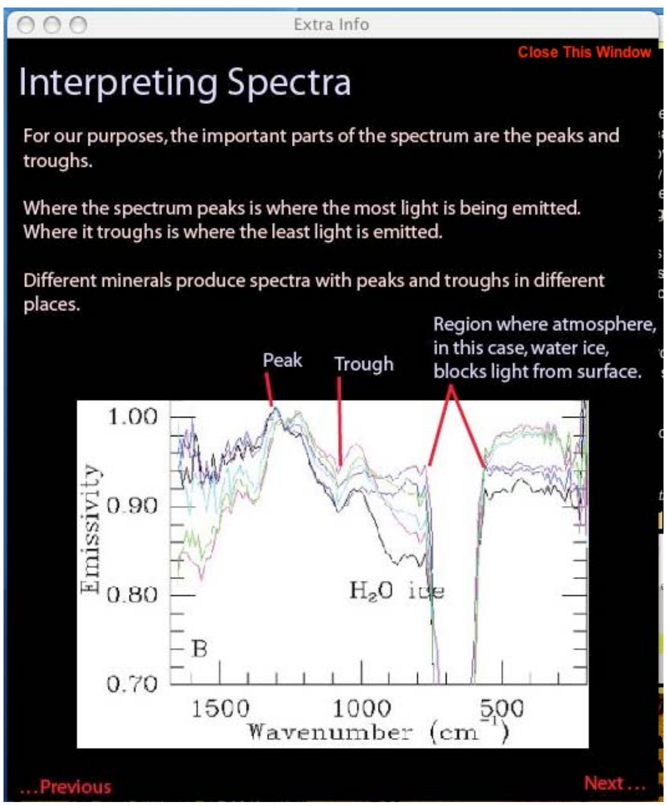
Within the mineral hunting exercise, the interactive maps allow students to infer relationships between thermal inertia, geology, topography, and albedo.

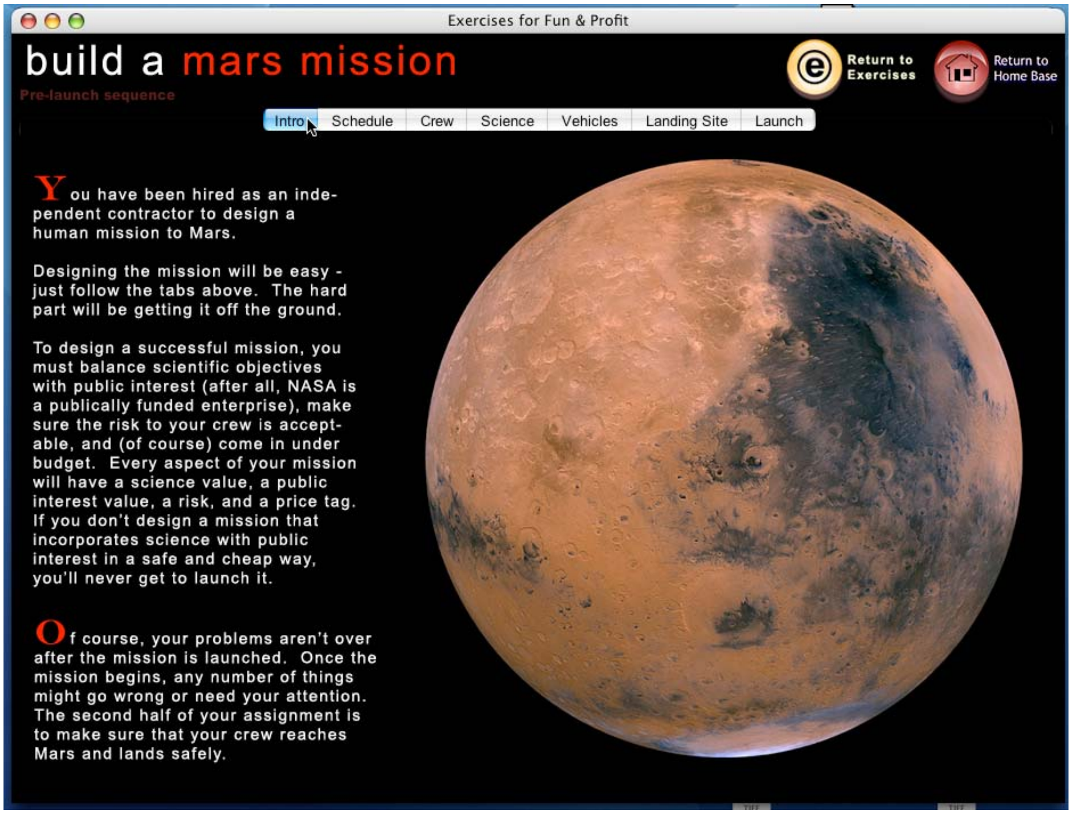




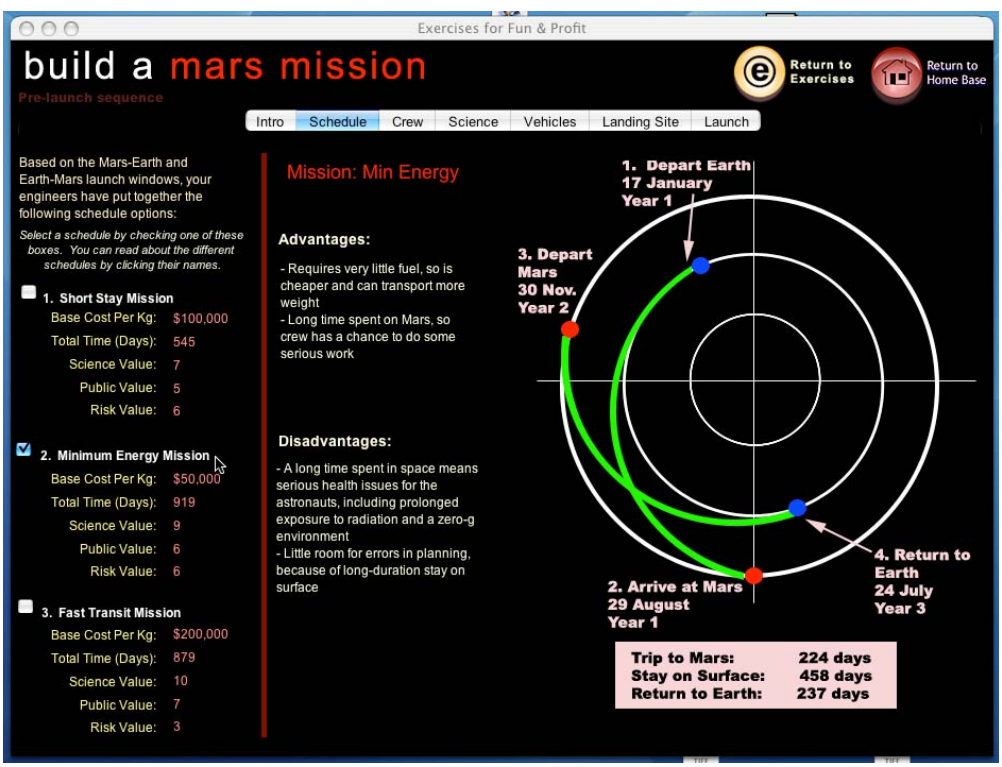
The spectral component of the mineral hunting exercise exposes users to how we identifiy minerals and compositions on the surface of Mars.

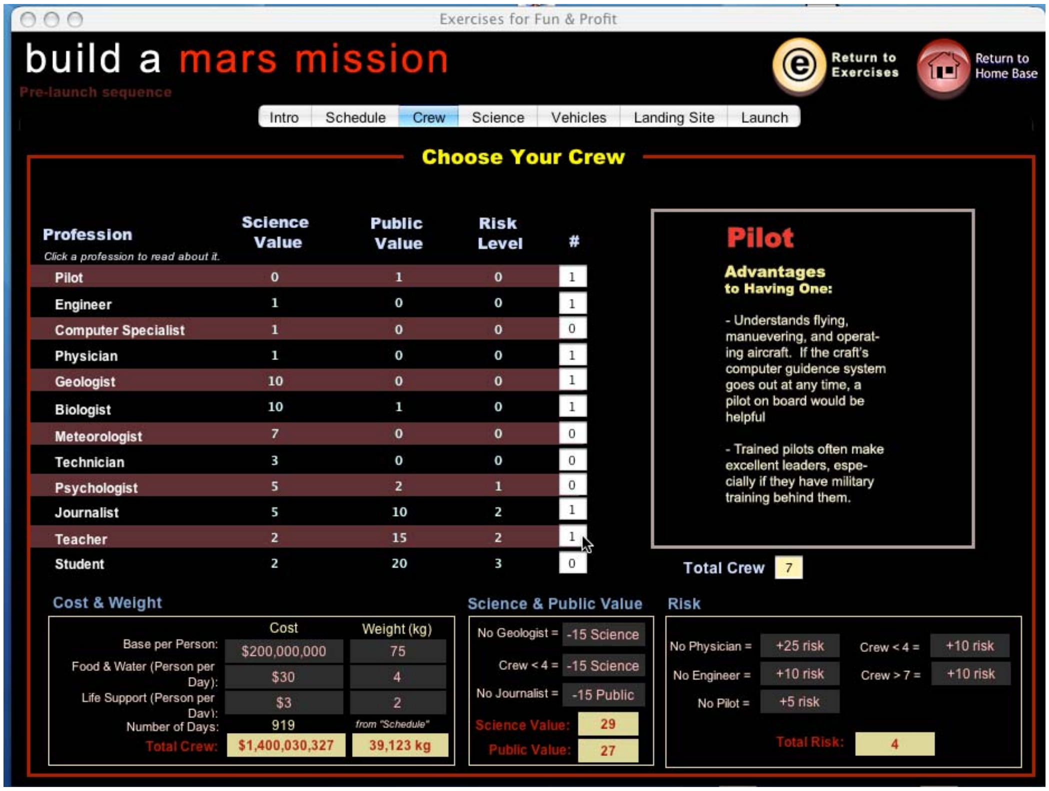
The mineral spectra used are actual spectra from Mars, obtained by the Thermal Emission Spectrometer (TES), and other satellites.

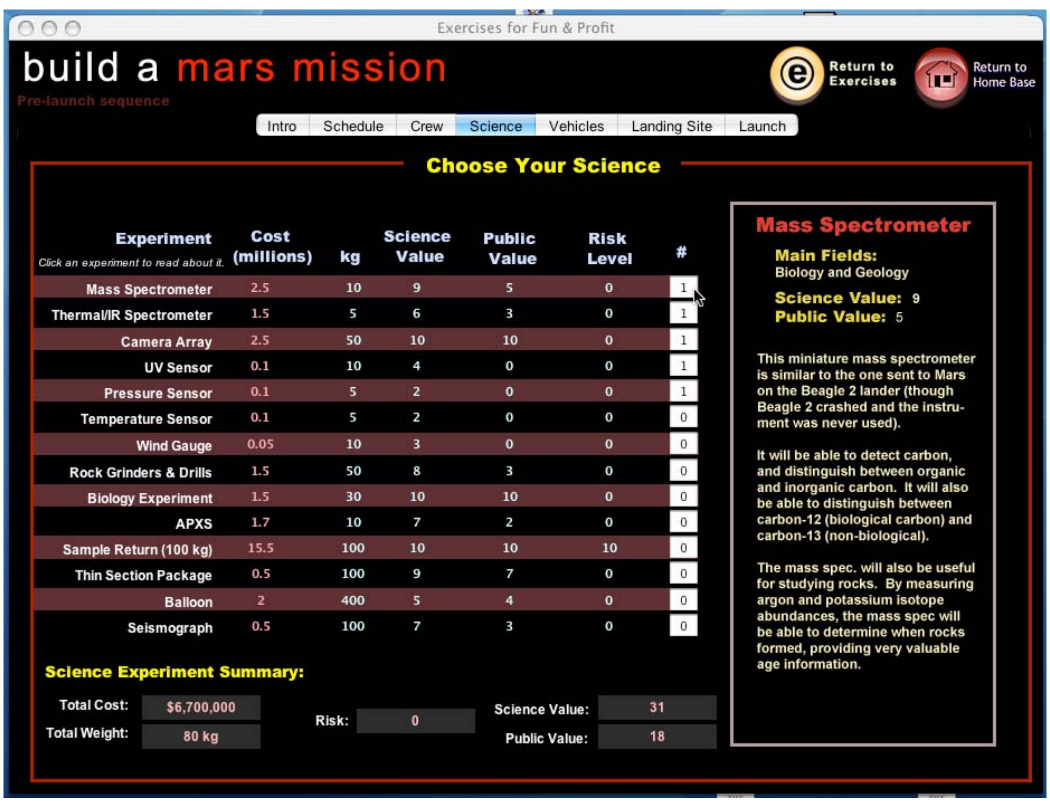


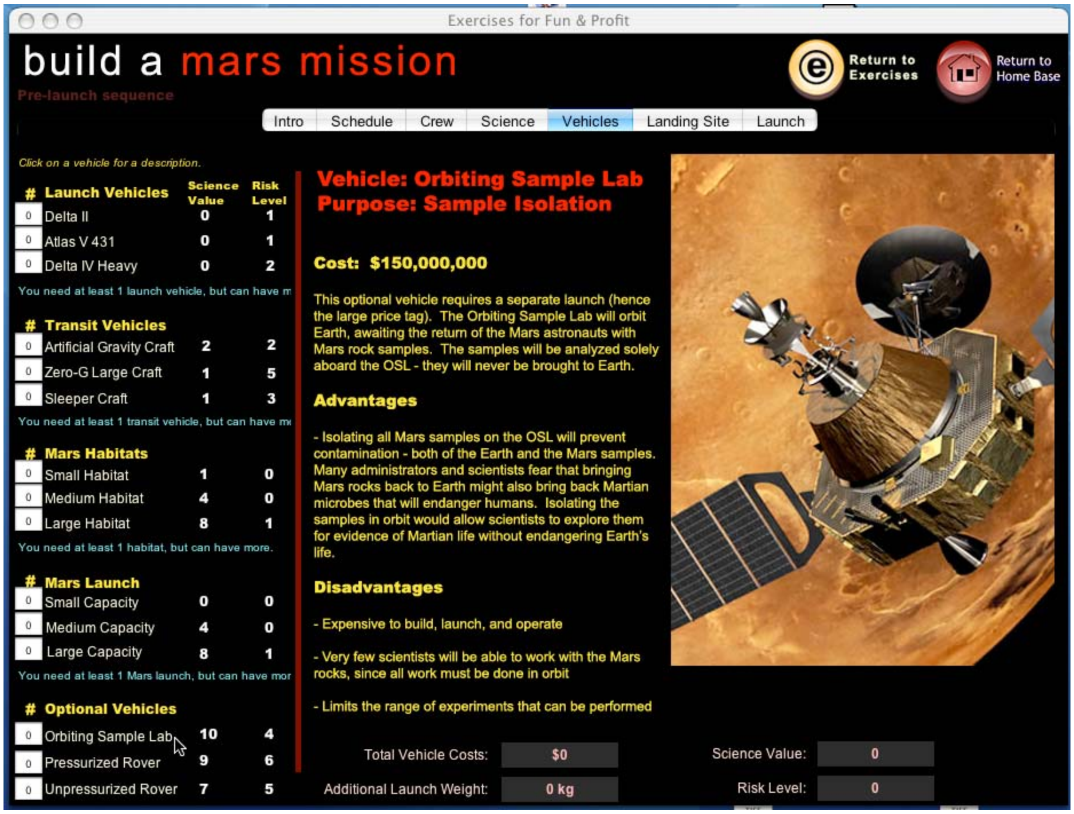


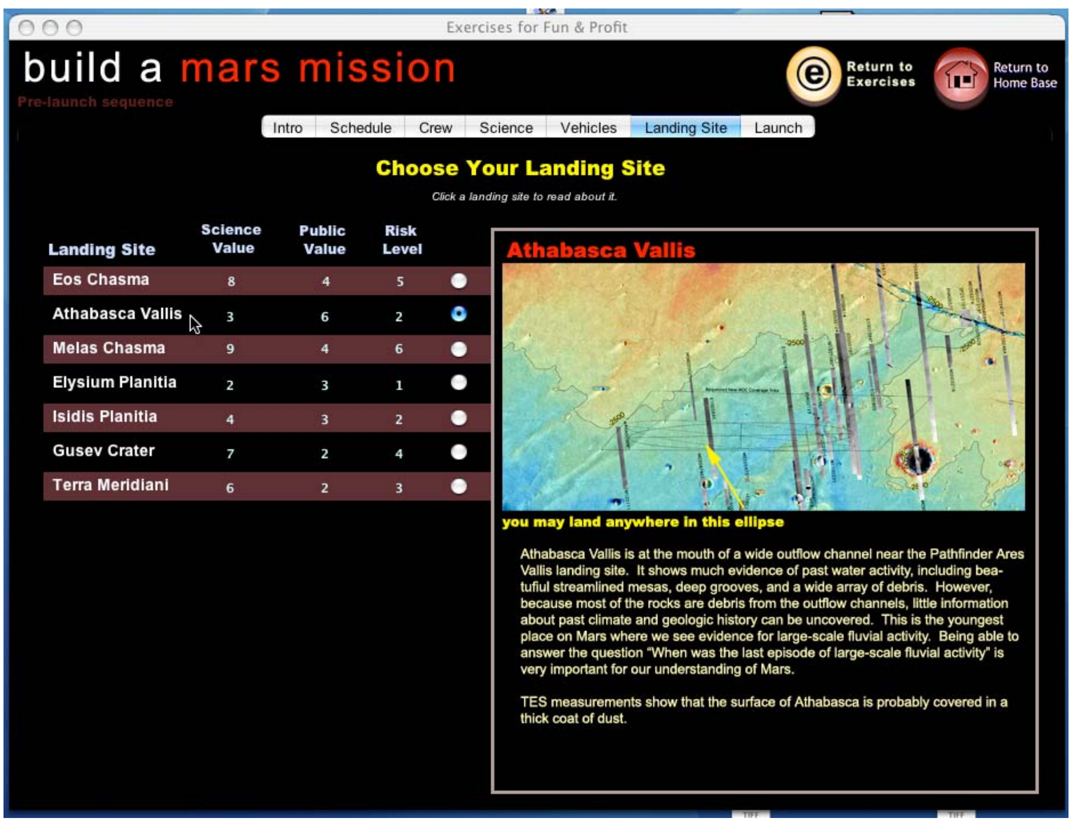
Exercises: Build a Mars Mission. The Build a Mars Mission exercise allows users to desgin a human mission to Mars, and asks them to think about some of the different issues involved in planning such a mission. See below.




Exercises for Fun & Profit
build a mars mission
Pre-launch sequence
Return to Exercises
Return to Home Base
Intro Schedule Crew Science Vehicles Landing Site Launch
Choose Your Crew
Profession
Click a profession to read about it.
Science Value
Public Value
Risk Level
#
Pilot 0 1 0 1
Engineer 1 0 0 1
Computer Specialist 1 0 0 0
Physician 1 0 0 1
Geologist 10 0 0 1
Biologist 10 1 0 1
Meteorologist 7 0 0 0
Technician 3 0 0 0
Psychologist 5 2 1 0
Journalist 5 10 2 1
Teacher 2 15 2 1
Student 2 20 3 0
Pilot
Advantages to Having One:
- Understands flying, manuevering, and operating aircraft. If the craft's computer guidance system goes out at any time, a pilot on board would be helpful
- Trained pilots often make excellent leaders, especially if they have military training behind them.
Total Crew 7
Cost & Weight
Cost
Weight (kg)
Base per Person: $200,000,000 75
Food & Water (Person per Day): $30 4
Life Support (Person per Day): $3 2
Number of Days: 919 from "Schedule"
Total Crew: $1,400,030,327 39,123 kg
Science & Public Value
No Geologist = -15 Science
Crew < 4 = -15 Science
No Journalist = -15 Public
Science Value: 29
Public Value: 27
Risk
No Physician = +25 risk
No Engineer = +10 risk
No Pilot = +5 risk
Crew < 4 = +10 risk
Crew > 7 = +10 risk
Total Risk: 4

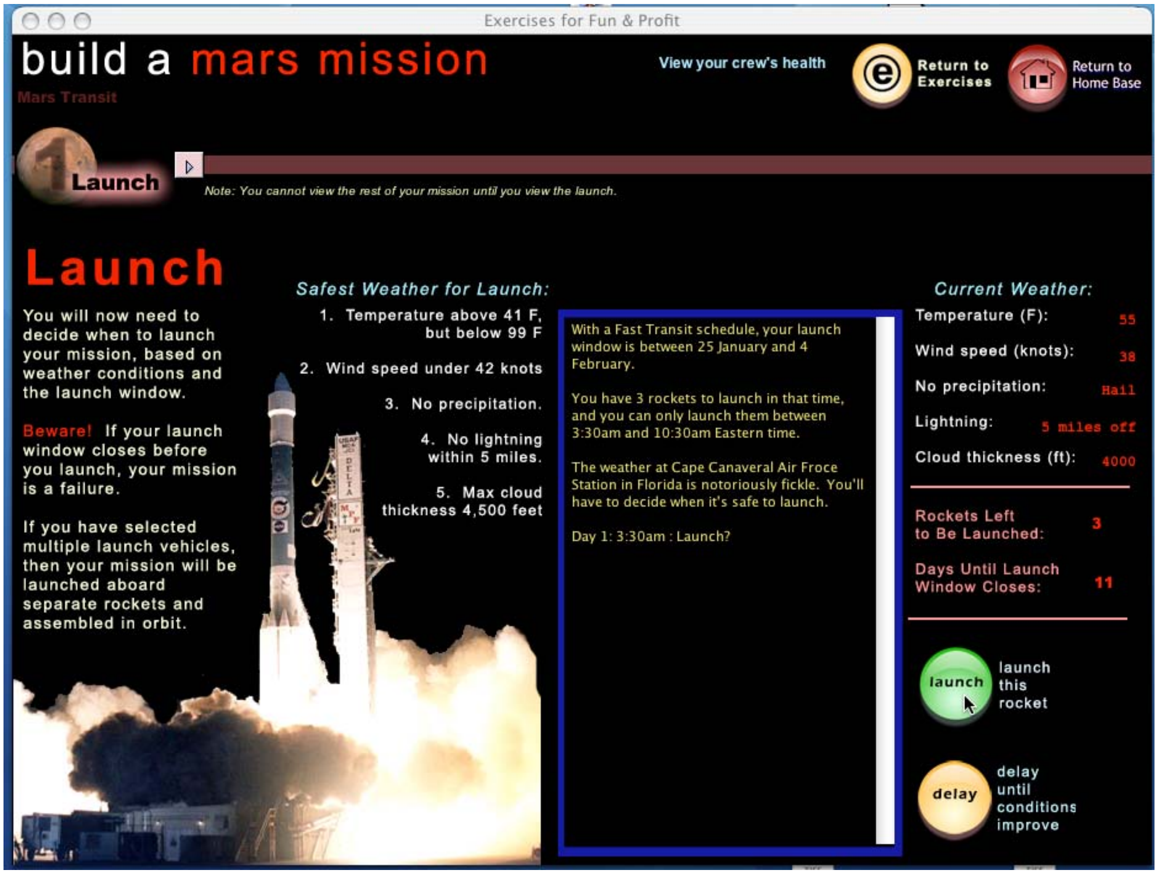

Exercises for Fun & Profit
build a mars mission
Pre-launch sequence
Return to Exercises
Return to Home Base
Intro Schedule Crew Science Vehicles Landing Site Launch
Choose Your Science
Experiment
Click an experiment to read about it.
Cost (millions)
kg
Science Value
Public Value
Risk Level
#
Mass Spectrometer 2.5 10 9 5 0 1
Thermal/IR Spectrometer 1.5 5 6 3 0 1
Camera Array 2.5 50 10 10 0 1
UV Sensor 0.1 10 4 0 0 1
Pressure Sensor 0.1 5 2 0 0 1
Temperature Sensor 0.1 5 2 0 0 0
Wind Gauge 0.05 10 3 0 0 0
Rock Grinders & Drills 1.5 50 8 3 0 0
Biology Experiment 1.5 30 10 10 0 0
APXS 1.7 10 7 2 0 0
Sample Return (100 kg) 15.5 100 10 10 10 0
Thin Section Package 0.5 100 9 7 0 0
Balloon 2 400 5 4 0 0
Seismograph 0.5 100 7 3 0 0
Mass Spectrometer
Main Fields: Biology and Geology
Science Value: 9
Public Value: 5
This miniature mass spectrometer is similar to the one sent to Mars on the Beagle 2 lander (though Beagle 2 crashed and the instrument was never used).
It will be able to detect carbon, and distinguish between organic and inorganic carbon. It will also be able to distinguish between carbon-12 (biological carbon) and carbon-13 (non-biological).
The mass spec. will also be useful for studying rocks. By measuring argon and potassium isotope abundances, the mass spec will be able to determine when rocks formed, providing very valuable age information.
Science Experiment Summary:
Total Cost: $6,700,000
Total Weight: 80 kg
Risk: 0
Science Value: 31
Public Value: 18


Exercises for Fun & Profit
build a mars mission
Pre-launch sequence
Return to Exercises
Return to Home Base
Intro
Schedule
Crew
Science
Vehicles
Landing Site
Launch
Click on a vehicle for a description.
Launch Vehicles
Science Value
Risk Level
0 Delta II 0 1
0 Atlas V 431 0 1
0 Delta IV Heavy 0 2
You need at least 1 launch vehicle, but can have m
Transit Vehicles
0 Artificial Gravity Craft 2 2
0 Zero-G Large Craft 1 5
0 Sleeper Craft 1 3
You need at least 1 transit vehicle, but can have m
Mars Habitats
0 Small Habitat 1 0
0 Medium Habitat 4 0
0 Large Habitat 8 1
You need at least 1 habitat, but can have more.
Mars Launch
0 Small Capacity 0 0
0 Medium Capacity 4 0
0 Large Capacity 8 1
You need at least 1 Mars launch, but can have mor
Optional Vehicles
0 Orbiting Sample Lab 10 4
0 Pressurized Rover 9 6
0 Unpressurized Rover 7 5
Vehicle: Orbiting Sample Lab
Purpose: Sample Isolation
Cost: $150,000,000
This optional vehicle requires a separate launch (hence the large price tag). The Orbiting Sample Lab will orbit Earth, awaiting the return of the Mars astronauts with Mars rock samples. The samples will be analyzed solely aboard the OSL - they will never be brought to Earth.
Advantages
- Isolating all Mars samples on the OSL will prevent contamination - both of the Earth and the Mars samples. Many administrators and scientists fear that bringing Mars rocks back to Earth might also bring back Martian microbes that will endanger humans. Isolating the samples in orbit would allow scientists to explore them for evidence of Martian life without endangering Earth's life.
Disadvantages
- Expensive to build, launch, and operate
- Very few scientists will be able to work with the Mars rocks, since all work must be done in orbit
- Limits the range of experiments that can be performed
Total Vehicle Costs: $0
Additional Launch Weight: 0 kg
Science Value: 0
Risk Level: 0

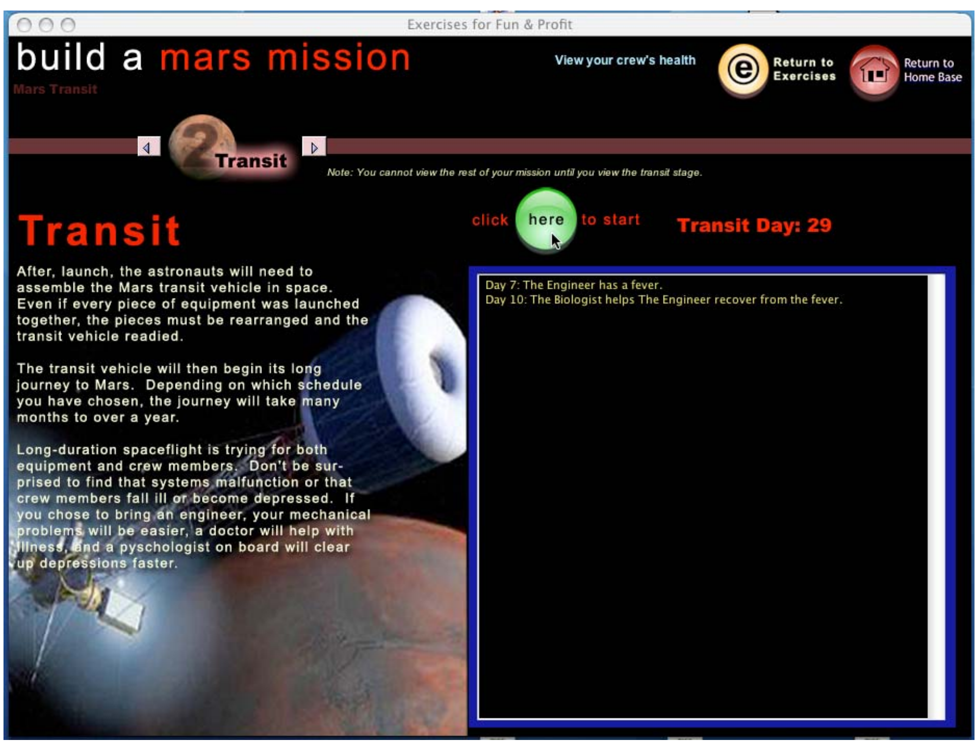

Exercises for Fun & Profit
build a mars mission
Pre-launch sequence
Return to Exercises
Return to Home Base
Intro
Schedule
Crew
Science
Vehicles
Landing Site
Launch
Choose Your Landing Site
Click a landing site to read about it.
Landing Site
Science Value
Public Value
Risk Level
Eos Chasma 8 4 5
Athabasca Vallis 3 6 2
Melas Chasma 9 4 6
Elysium Planitia 2 3 1
Isidis Planitia 4 3 2
Gusev Crater 7 2 4
Terra Meridiani 6 2 3
Athabasca Vallis
you may land anywhere in this ellipse
Athabasca Vallis is at the mouth of a wide outflow channel near the Pathfinder Ares Vallis landing site. It shows much evidence of past water activity, including beautiful streamlined mesas, deep grooves, and a wide array of debris. However, because most of the rocks are debris from the outflow channels, little information about past climate and geologic history can be uncovered. This is the youngest place on Mars where we see evidence for large-scale fluvial activity. Being able to answer the question "When was the last episode of large-scale fluvial activity" is very important for our understanding of Mars.
TES measurements show that the surface of Athabasca is probably covered in a thick coat of dust.

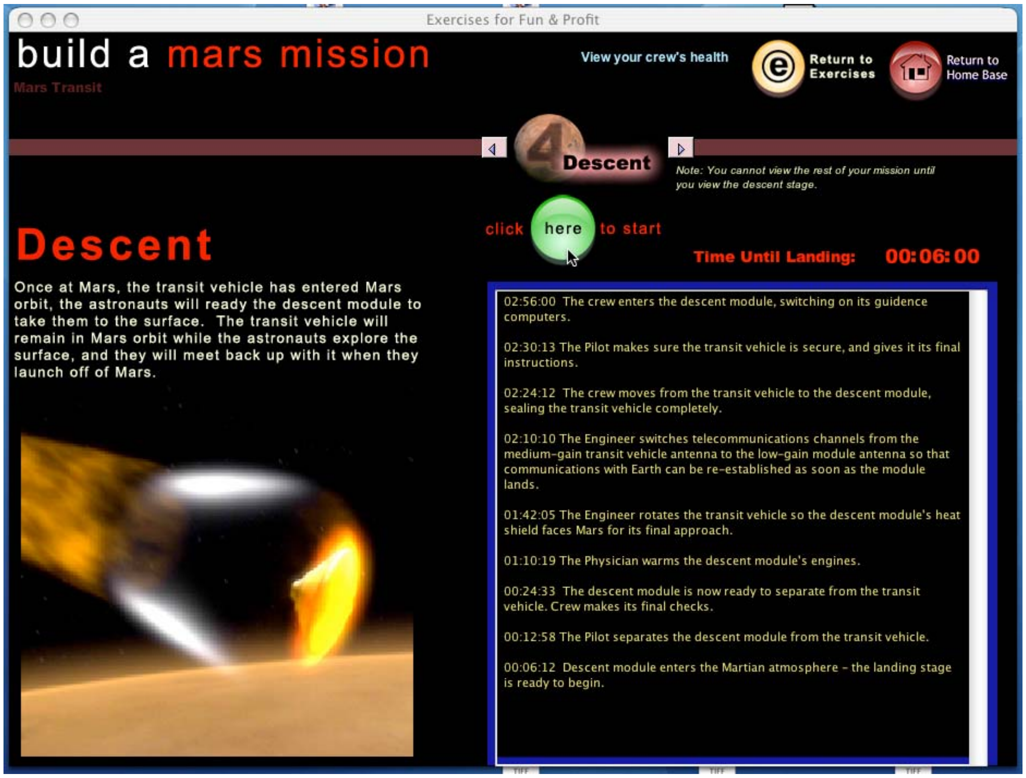
Before the mission can be launched, the mission must satisfy several requirements: it must be under budget (though the user can petition Congress for additional funds), must have an acceptable risk level, sufficient public interest, high scientific value, and come in under weight limits. Also, several logistical requirements must be met. For example, if the user has decided to bring samples back, he/she must have specified a plan for quarrentining or decontaminating the samples.

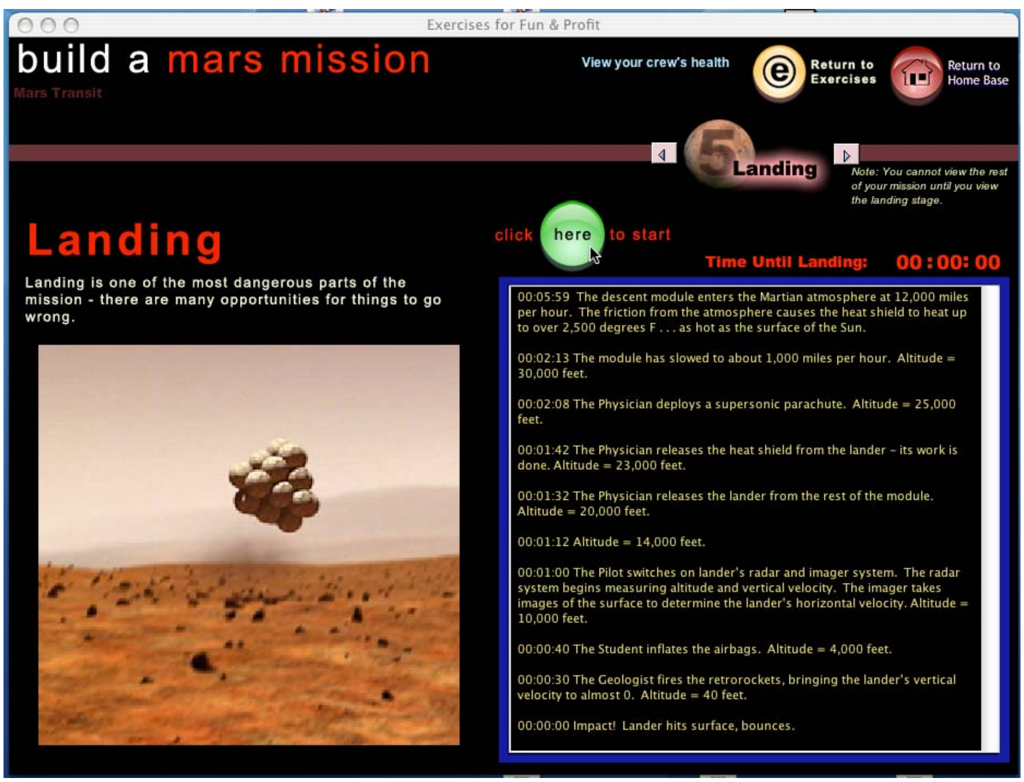
Once a user has met all the requirements for a mission, he/she can launch the mission and follow its progress . . . .



Once cleared for launch, the user must actually launch the mission, choosing launch times based on weather conditions at Cape Canaveral. If the user chooses dangerous launch conditions, the risk of the mission blowing up on launch increases.




Exercises for Fun & Profit
build a mars mission
Mars Transit
View your crew's health
Return to Exercises
Return to Home Base
4 Descent
Note: You cannot view the rest of your mission until you view the descent stage.
click here to start
Descent
Time Until Landing: 00:06:00
Once at Mars, the transit vehicle has entered Mars orbit, the astronauts will ready the descent module to take them to the surface. The transit vehicle will remain in Mars orbit while the astronauts explore the surface, and they will meet back up with it when they launch off of Mars.
02:56:00 The crew enters the descent module, switching on its guidence computers.
02:30:13 The Pilot makes sure the transit vehicle is secure, and gives it its final instructions.
02:24:12 The crew moves from the transit vehicle to the descent module, sealing the transit vehicle completely.
02:10:10 The Engineer switches telecommunications channels from the medium-gain transit vehicle antenna to the low-gain module antenna so that communications with Earth can be re-established as soon as the module lands.
01:42:05 The Engineer rotates the transit vehicle so the descent module's heat shield faces Mars for its final approach.
01:10:19 The Physician warms the descent module's engines.
00:24:33 The descent module is now ready to separate from the transit vehicle. Crew makes its final checks.
00:12:58 The Pilot separates the descent module from the transit vehicle.
00:06:12 Descent module enters the Martian atmosphere - the landing stage is ready to begin.


Exercises for Fun & Profit
build a mars mission
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Return to Exercises
Return to Home Base
5 Landing
Note: You cannot view the rest of your mission until you view the landing stage.
click here to start
Landing
Time Until Landing: 00:00:00
Landing is one of the most dangerous parts of the mission - there are many opportunities for things to go wrong.
00:05:59 The descent module enters the Martian atmosphere at 12,000 miles per hour. The friction from the atmosphere causes the heat shield to heat up to over 2,500 degrees F . . . as hot as the surface of the Sun.
00:02:13 The module has slowed to about 1,000 miles per hour. Altitude = 30,000 feet.
00:02:08 The Physician deploys a supersonic parachute. Altitude = 25,000 feet.
00:01:42 The Physician releases the heat shield from the lander - its work is done. Altitude = 23,000 feet.
00:01:32 The Physician releases the lander from the rest of the module. Altitude = 20,000 feet.
00:01:12 Altitude = 14,000 feet.
00:01:00 The Pilot switches on lander's radar and imager system. The radar system begins measuring altitude and vertical velocity. The imager takes images of the surface to determine the lander's horizontal velocity. Altitude = 10,000 feet.
00:00:40 The Student inflates the airbags. Altitude = 4,000 feet.
00:00:30 The Geologist fires the retrorockets, bringing the lander's vertical velocity to almost 0. Altitude = 40 feet.
00:00:00 Impact! Lander hits surface, bounces.

Random Image Generator: Finally, for users just wanting to marvel and the beautiful images of Mars that have come back in recent years, the project includes a random image generator that produces a new image (and caption) each time it is loaded.

Table 2: The Final Tally

Images:	682
Captions:	35,000 words - 85 pages
Articles:	34,000 words - 80 pages
Maps:	185
Lines of Code:	Incalculable.

Discussion

As it stands, this project can be used as a teaching tool or reference for undergraduates, and for others interested in science.

The next stage in this project will be to create more exercises and tours, add more in-depth articles, and expand the caption data and images. Though this project served as my Division III thesis for Hampshire College, I will continue working on this project throughout graduate school.

Acknowledgements

The author gratefully acknowledges Chris Condit for his constant advice, support, and inspiration in producing this project. She would also like to thank her Hampshire Division III committee members: Darby Dyar, Steven Roof, and Kenneth Hoffman.

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