Mars Landing Site Lab
ASTR1 - DUE August 21, 2002 at 9:00 PM

Overview

Your goal is to choose landing sites for a Mars Exploration Rover (MER)-type mission. You will define the science goals for this mission and pick a landing site that best meets these goals. You will address safety concerns for the lander. You will write a compelling case for two landing sites – this is generally a competitive process.

Resources

- Since you'll be making decisions based on satellite photography of Mars, we'll provide a "Beginner's Guide to Martian Landforms" on the ASTR1 web site.
- You'll need to look at the NASA's Mars Landing Site web page at <http://marsoweb.nas.nasa.gov/landingsites>. In fact, to keep this lab to a reasonable size, we'd like you to restrict your landing site choices to one of the seven Mars Exploration Rover (MER) final candidates after reviewing them (see <http://marsoweb.nas.nasa.gov/landingsites/mer2003/topsites/final/>).
- We've put a clickable Mars map on the ASTR1 website. It only takes you to a resolution of 1 km per pixel, but it may be useful to show you the global context of a specific site.
- One site, Gusev crater, is discussed in an essay written for elementary school students. This essay is online.
- A series of essays written by Mark Caplinger of Malin Space Science Systems are also online. These provide a brief overview of martian channels, volcanoes, polar caps. They are pretty fast reading.
- Finally, we point you to the Mars Exploration Rover web site (<http://athena.cornell.edu>, <http://athena.cornell.edu/the_mission/index.html>). This site should tell you the capabilities of the rover.

Procedure (What you have to do...)

1. *Write the group 1-3 goals, and write a paragraph justifying your choices.* This section is admittedly subjective – what do *you* think are the most important things to learn on Mars? As a reference point, the unifying theme in most previous landing site selections has been water. Where and when did

it flow on the martian surface, and could it have supported life?

GROUP ONE GOALS

GROUP TWO GOALS

GROUP THREE GOALS

RATIONALE FOR GOAL SELECTION

2. *Summarize the advantages of the seven MER final landing site candidates, not more than a paragraph each.* This requires you to read the abstracts in support of each site, and look at the MOC close-up images of each site. A sentence describing what the site is (a canyon, a cratered highland, etc.) and a few sentences describing why it has been considered as a MER final seven landing site candidate.

   By the way, one nice way to compare the landing sites is to make a table with the seven sites as column headers and each of your goals as rows. Check off any goals that can be addressed by a rover at each landing site. The estimated safety of the site could be an additional row. The seven sites are

- Terra Meridiani (2.07°S, 6.08°W)
- Gusev Crater (14.82°S, 184.85°W)
- Elysium Planitia (14.5°N, 244.63°W)
- Melas Chasma (8.88°S, 77.48°N)
- Isidis Planitia (4.31°N, 271.97°W)
- Athabasca Vallis (8.92°N, 205.21°W)
- Eos Chasma (13.34°S, 41.39°W)

3. Pick your favorite landing site. Write an abstract in support of your choice. Include an image of the site, the landing ellipse, and a strawman rover expedition around that site (drawn on the site image). Remember that the rover can travel about 100 meters per day, and will operate for 90 days.

   Two things you may want to look at: some abstracts written for other sites and notes (courtesy of Dr. Gulick) from NASA's Pasadena Landing Site Workshop held on Oct 18-19, 2001 (included). These notes are a rough transcript of the workshop, but may be the best place to start to learn what the attending scientists thought of the various landing sites.

Part One: Science Goals

Here we list many of the yet-unanswered questions regarding Mars. Your job is to judge which are the most compelling questions, and make your own list of science goals to answer these questions. Set up your science goals in three groups of descending priority. Each group should have three or four goals. Group One goals are most important; these must be addressed by your choice of landing site. Group Two goals are also important, but can be partially addressed by you choice of landing site. Group Three goals are gravy - it would be nice to get them, but not at the expense of Group One or Two goals.

Partial List of Outstanding Questions (you may add others) in no particular order:

- *Did ancient Mars have a thicker atmosphere*?
- *Did ancient Mars have liquid water on its surface*? Can you land near a channel or river bed and date it?
- *How did the canyons form*?
- *What are the absolute ages of surfaces with varying crater densities*? Assume that the rover can radioactively date rocks that it can touch. You could assign an absolute age to a region, as opposed to relative ages based on the number of craters per square kilometer.
- *What is the composition of the martian crust*? The rover can grind away a surface layer and take a spectrum of the uncovered rock.
- *What is the composition of the martian mantle*? Best bet might be to sample lava outflow from a volcano.
- *Is there residual mineralogical evidence of a former ocean on Mars*? For example, the mineral hematite should be an abundant lag deposit after an ocean has dried up.
- *Did ancient Mars have plate tectonics*? This question is prompted by finding anomalous magnetic "stipes" in the martian crust that may be analogous to new terrestrial crust produced in mid-ocean ridges. There are anomalous magnetic regions that are pop-

ular landing site candidates.

- *Did ancient Mars have an internal magnetic field*? Land in the anomalous magnetic regions to find out.
- *Does Mars have unique isotopic ratios of D/H or of noble gases*? Can probably answer this one from any site. These ratios may constrain escape rates or help to identify Mars meteorites containing trapped gas bubbles.
- *Does Mars have water frozen under its surface*? Yes it does, according to the gamma ray spectrometer, which detects gamma rays produced when charged particles interact with hydrogen compounds in the top meter of the surface.
- *How has Mars' climate and atmosphere changed in the past hundred thousand years*? A polar lander could look at layers in the martian ice cap. However, MER is not currently equiped to obtain a core sample from an ice cap.
- *What is the internal structure of Mars*? Probably requires a network of seismic sensors. While this could answer lots of mysterious questions (such as why some of Mars' volcanoes sit on a large bulge - is the underlying rock especially low in density?), the MER does not have seismic sensors to deploy.
- *How important is wind as a mechanism for erosion*? Are some channels cut by wind instead of water? Have some craters been totally covered by wind-driven dust?
- *How do dust storms begin and end*? Probably requires a landing site nearer to the equator, which might conflict with a search for subsurface ice (currently found polewards of 45°).
- *What conditions lead to dust devils* (small dust tornadoes)? Dust devils may be critical in the onset of dust storms. Mars' atmosphere is so thin that it may be difficult to lift dust particles into the air.
- *How does the pressure vary during the year*? Long-term and short-term pressure monitoring is critical to understanding weather patterns on Mars.
- *Does the transport of atmospheric CO_2 govern the surface temperature*? CO_2 can heat the surface when it condenses or cool the surface when it sublimates.
- *Are there any active volcanoes on Mars*?
- *Are any gases* (especially greenhouse gases) *escaping from the planet's interior*? Good question - any way to find out besides landing right in a volcano?

- *Are there any marsquakes*? Where and how strong? Probably impossible for MER - wait for a mission with seismic sensors.
- *How did the amount of water on Mars change*? Hint: look at terraced shorelines of sedimentary layers. This addresses a continuing mystery - where did the surface water go and how did the ancient Mars climate change from one that supported liquid water.
- *How were channels and drainage features formed*? How much water was required, and how long did the erosion take?
- *Are there any biotic molecules on Mars*? For some people, this is the main question.
- *Are there signs of life in the fossil record* (i.e., buried in sediment)?
- *How much radiation does the surface receive*? A useful thing to know if you plan on sending astronauts to Mars. Assume that MER has a radiation counter.

Some Basic Hints for Parts 2 and 3:

Here are some things that people look for in a landing site.

- *Diversity*. Lots of different things in one site. For example, a good site might be located near (a) the tail end of a channel, (b) next to some crater ejecta, (c) downstream from volcano outflow, and (d) near some sedimentary layering. The Pathfinder site was chosen largely because of its diversity (but not a lot of diversity was encountered, actually.)
- *Safety*. Make sure the ground is smooth, level, and the winds are not too high. Unfortunately, this requirement often conflicts with all of the other requirements. You'll want to use close-up Mars Orbital Camera (MOC) images to scout a landing site, and Mars Orbital Laser Altimeter (MOLA) to assess surface roughness and slope. Get these from the landing site web site.
- *Best Examples of (X)*. If you decide that sediments are your top goal, then pick a site with the BEST sediments (best preserved, formed over the longest period of time, easy for a rover to access, etc.) One site, Gale crater, was dropped because Gusev was judged to be a better sediment site.