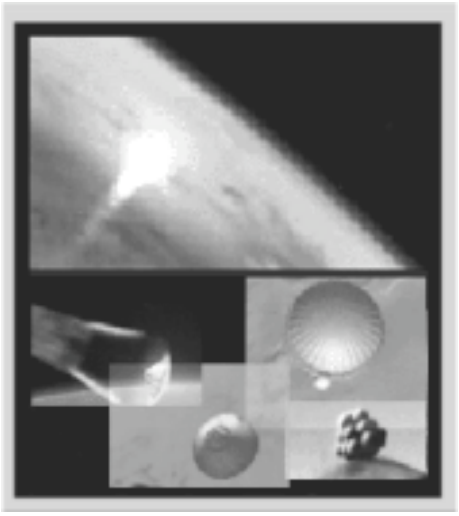
Name: _____

Touchdown: Landing Systems

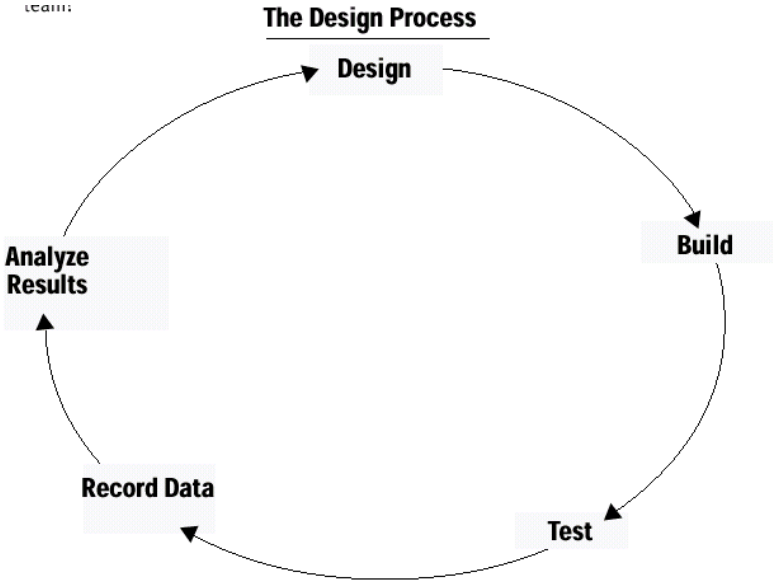
Overview



The Mars Exploration Rovers launched in June, 2003 on a 7 month journey to Mars. The rovers' mission is to characterize the geology of two sites on Mars. These sites are particularly interesting because they hold clues to past liquid water on the surface of Mars. On Earth, we find life wherever there is liquid water. If there was liquid water on the surface of Mars, was there life?

Before the robotic geologists can start their mission, they must survive their landing. They travel tens of millions of miles to get to Mars. When they arrive, they plunge through Mars' atmosphere at thousands of miles per hour. If they impact the surface at this speed, they won't be able to do much science! So, engineers must devise a system to safely land the rovers on the surface.

Engineers have a specific process that they use when facing a problem. Before they begin, they must carefully state the problem and determine the constraints that they have to work within. An important part of defining the problem, is to understand the science behind what is happening. They also need to define "metrics." A metric is a measurement that can be made to determine how successful a design solution is. After the problem is defined, engineers design a solution on paper or through computer modeling, build a model, test the model, record data from the test, and analyze the results of the tests to see how successful their design was. Engineers then use this analysis to improve their solution and start the process of design, testing and analysis over. Often, they go through this process many times before arriving at the best solution.



Problem
In this activity, you will design a landing system that will safely deliver a raw egg to the ground from a 30 foot drop.

The Science Behind the Problem
The first step in defining our problem is to learn about the science behind an egg crashing into a surface. As a class, you will model an impact of an egg into a surface.

1. If you throw an egg against a wall, it will break. Why?

After your teacher shows you the experimental setup, answer this question.

2. Can any of your classmates throw the egg hard enough so that it will break? Why or why not?

Conduct the experiment.

3. Does the egg break? Why or why not?

4. After your teacher explains the science behind the experiment, explain in your own words what you need to do to keep the egg from breaking when it hits the surface. At this point, you do not need to describe HOW you are going to do it, just what you think you need to do.

Constraints and Metrics

Constraint
Your landing system, including the raw egg, must fit within a 8" x 8" cube.
You can not use any electrical devices or chemical reactions.

Additional constraints:

Metrics

Safety of Egg

Condition	Points
Shell intact, yolk intact	50
Shell cracked, yolk intact	35
Shell intact, yolk broken	15
Shell cracked, yolk broken	FAILURE

Mass

When it comes to spacecraft design, mass is money! A specific rocket only has the ability to launch a spacecraft with a certain mass. If your mass is too great, you need to buy a more powerful, and much more expensive rocket. Additionally, if your spacecraft is lighter, you can add more instruments so that you can do more science when you get to your destination. Because of this, engineers need to make their spacecraft as light as possible.

You must find the mass of your landing system (not including the mass of the egg) before testing it. Your mass should be measured in grams.

Use the following formula to determine the score for your test. (If the shell and yolk are both broken, the score is 0)

SCORE = (Safety of Egg) / mass

The best landing system will have the highest score.

Example:

Your landing system has a mass of 100g and delivers the egg with the shell and yolk both unbroken, your score would be.

SCORE = 50/100 = 0.5

1. What would you have to do to improve your score in this example?

Design

In order to prove that your design is valid, you must keep good notes. Keep a journal of your design process on a separate piece of paper. You will be able to design at least two different landing systems. Your entry for each system should look like this:

Sketch	Test Result	Score	Analysis
	Mass = 250g Egg = 15pts	16.67	The egg is not protected, consider using lighter materials for the frame and additional cushioning.

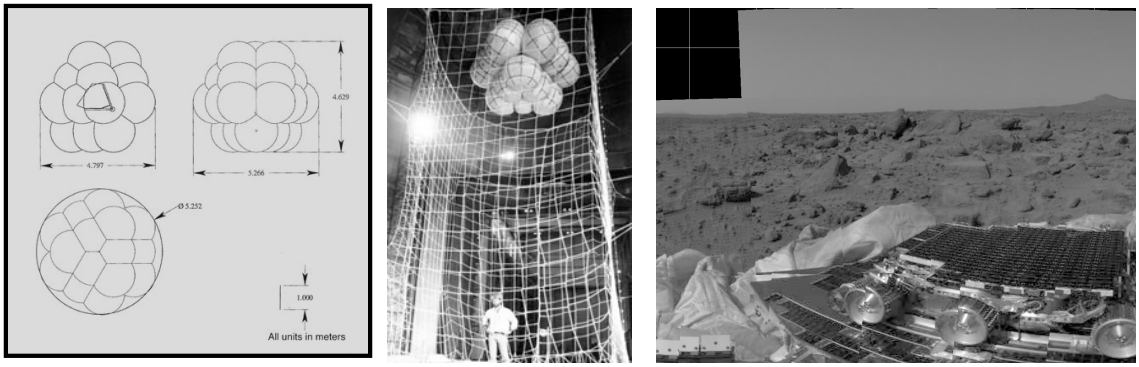
A Solution for Mars

In the early 1990's NASA was looking for a cost effective way to land a spacecraft on Mars. Tom Rivellini, a 25 year old engineer from NASA's Jet Propulsion Laboratory, and a few colleagues went to work on the problem. They designed an innovative system of airbags that would allow the lander to bounce across the surface of Mars. Each bounce would dissipate some energy and the lander would eventually come to a gentle stop on the surface. The group designed and built a model of the system and then tested it. The first test was a complete failure! However, they saw signs that it would work, so set to work redesigning and testing their system. After a year of testing, they finally had developed a system that had a reasonable (based on their constraints and metrics) chance of working. In the summer of 1996, this airbag landing system successfully delivered Mars Pathfinder and the microwave-sized, Sojourner rover to the surface of Mars.

The airbag solution for Mars Pathfinder worked so well that NASA decided to use the system for the twin 2003 Mars Exploration Rovers, "Spirit" and "Opportunity."

For more information check out these sites:

- http://mars.jpl.nasa.gov/
- http://mars.jpl.nasa.gov/MPF/mpf/edl/edl1.html
- http://mars.jpl.nasa.gov/mer/mission/spacecraft_edl.html



Design (left), testing (middle), and success (right) of the airbag landing system for the Mars Pathfinder mission.