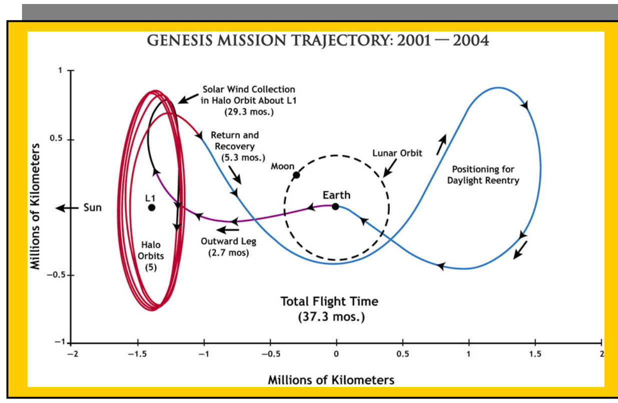
Destination L1: A Thematic Unit

L1 or Bust!

STUDENT TEXT

KEPLER REVISITED



From the activities that you completed on Kepler's three laws of planetary motion, you have learned that planets travel in elliptical orbits around the sun. The sun is the focus of their elliptical orbits. (Kepler's First Law). You learned that the eccentricity of these elliptical orbits is very small (similar to circles). You also discovered that as a planet orbits the sun, it sweeps out equal areas in equal times (Kepler's Second Law). Finally, you learned that the closer a planet is to the sun, the faster it travels in its orbit (Kepler's Third Law).

The activities dealing with Kepler's laws are really about how planets orbit the sun. A planet's orbit is like the path of an airplane traveling around the Earth, or the road on which a person drives in a car. They all represent the path that is used during a trip. In the case of the planets, it's a trip around the sun. In the case of the Genesis spacecraft, the trajectory represents the path that it takes as it travels to its destination and orbit at L1, as well as its return to Earth.

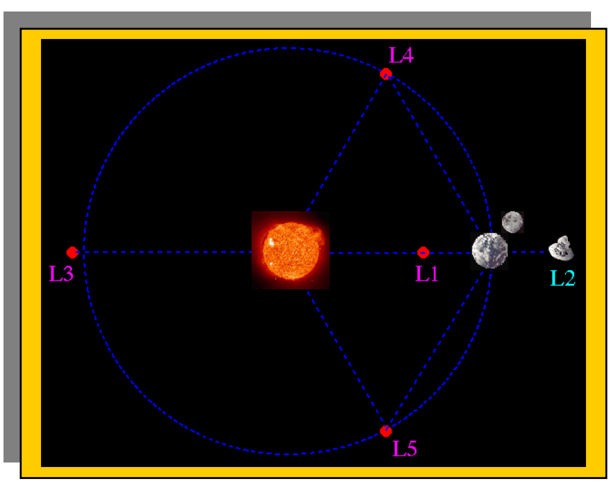
LAGRANGE POINT 1

According to Kepler's Third Law, if the Genesis spacecraft traveled around the sun in an orbit smaller than the Earth's, the orbit would have a shorter period and would move faster. Its distance would grow until the spacecraft and the Earth would be very far apart. If the Genesis spacecraft was placed between the Earth and the sun, the opposing pull of the Earth would offset the pull of the sun, allowing the spacecraft to orbit the sun more slowly. If the distance is properly chosen, the orbital motion will match that of the Earth, allowing the two to stay together throughout the Earth's annual trip around the sun. The place where the gravity is balanced between the Earth and the sun is this balance point. It is called the LaGrange Point 1 (L1) and is named after Joseph-Louis LaGrange, the mathematician who discovered it. This is the reason why the scientists and engineers who planned the Genesis mission chose L1 as the place where the Genesis spacecraft will orbit, rather than orbiting the sun itself. L1 provides a direct line of sight to the sun, making it an ideal place to catch solar wind particles.

L1 is one of five points in space around the Earth and the sun called LaGrange points. L1 is located about 1.5 million kilometers between the Earth and the sun. It is the point where the gravity between the sun and the Earth is balanced. In the Sun-Earth system, the L1 point is between the two massive bodies. L2 is past the Earth, and past the sun is L3. L4 and L5 are at the apex of equilateral triangles with the massive bodies at the vertices (Figure 1). L4 is usually associated with the leading triangle, L5 the trailing. Objects can settle into an orbit around one LaGrange point, although they may require course corrections to maintain their orbital path. Several missions have been stationed near L1. The following is a short summary of these missions.

McREL

Missions To LaGrange Point 1		
Mission to L1	Date Launched	Objectives
Genesis	August 8, 2001	1. To obtain precise measures of solar isotopic abundances. 2. To obtain greatly improved measures of solar elemental abundances. 3. To provide a reservoir of solar matter for 21st century science research, eliminating the need for future solar wind sample return mission.
The Advanced Composition Explorer (ACE)	August 25, 1997	1. Comprehensive and coordinated composition determinations. 2. Observations spanning broad dynamic range. 3. Investigations of the origin and evolution of solar and galactic matter.
Solar and Heliospheric Observatory (SOHO)	December 2, 1995	1. Study the internal structure of the sun, its extensive outer atmosphere, and the origin of the solar wind.
WIND	November 1, 1994	1. Provide complete plasma, energetic particle, and magnetic field input for magnetospheric and ionospheric studies. 2. Determine the magnetospheric output to interplanetary space in the up-stream region. 3. Investigate basic plasma processes occurring in the near-Earth solar wind. 4. Provide baseline ecliptic plane observations to be used in heliospheric latitudes from ULYSSES.



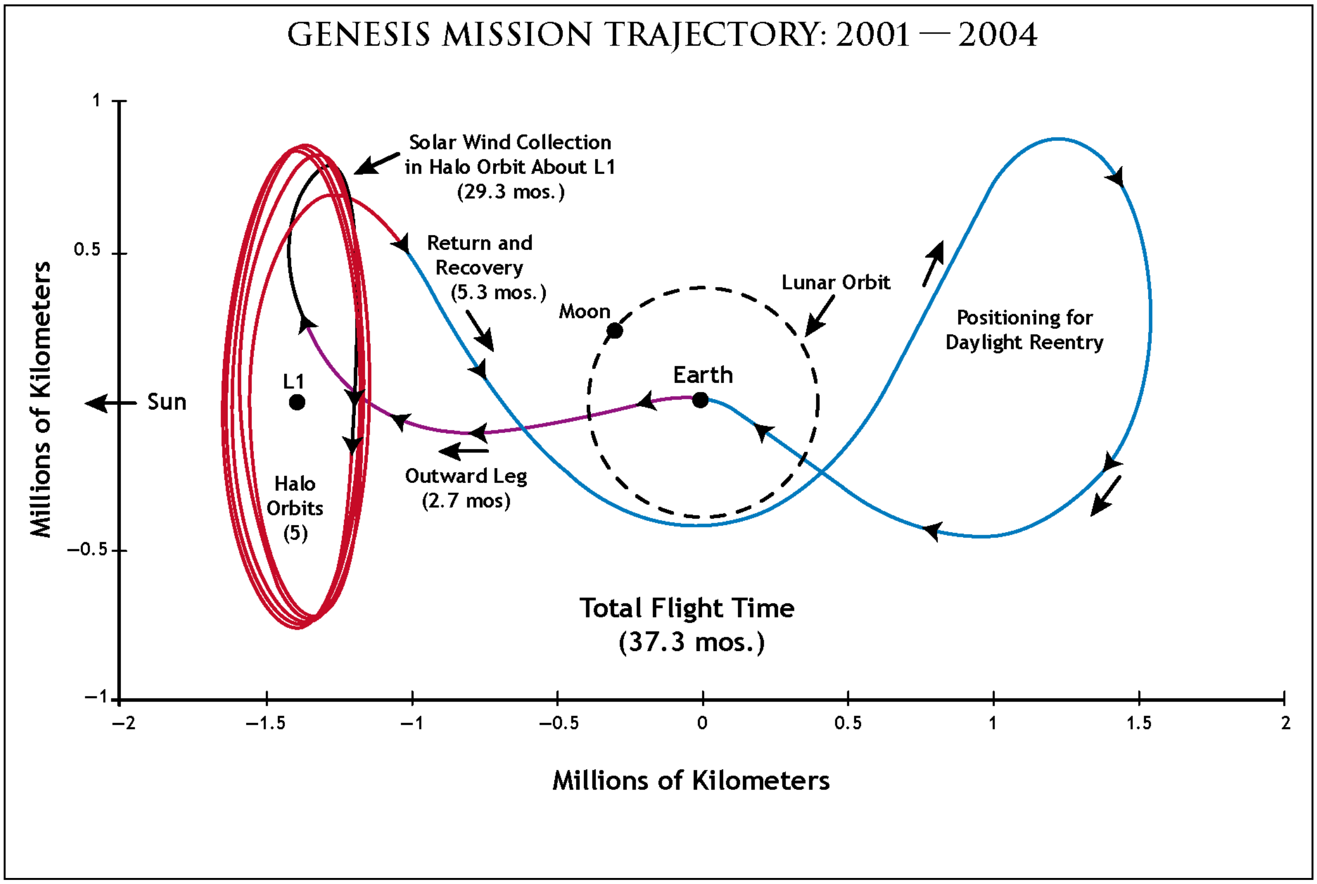
The five LaGrange Points about the sun.

FROM ROCKET TO HELICOPTER

The Genesis spacecraft began its journey into space mated to a Delta rocket (see *Dynamic Design: Launch and Propulsion*). Once the Genesis spacecraft was launched, it traveled toward the sun and its orbit point around L1. During this trip, the most critical aspects in driving the spacecraft on its trek to L1 were the trajectory correctional maneuvers. These course corrections were done to fix any **vector** errors left over from the launch vehicle. It was important that this correction be done soon after launch, since the longer the flight team waited, the larger the correction would be, and more fuel would be needed to make the correction. The first correction was one of perhaps 20 that will be required for the Genesis spacecraft between launch and recovery. The two most important corrections are the first one and the last one prior to the helicopter capture over the Utah desert in 2004.

The science canister from the spacecraft ends the journey by being captured by a helicopter! (See *Genesis: Search for Origins* video clip.) Between these two events the spacecraft travels along a planned trajectory.

Study the following trajectory diagram and answer the questions that follow.



1. At what distance does the Genesis spacecraft cross the moon's orbit?

2. How long does it take for the Genesis spacecraft to arrive at L1?

3. How many orbits does the Genesis spacecraft make around L1?

4. What is the approximate diameter of each of these orbits?

5. How many months does each orbit take?

6. Describe the Genesis spacecraft's trip back to Earth.

7. Why does the Genesis spacecraft travel around L2?

8. What year does the Genesis spacecraft return to the Earth?

9. How many years is the Genesis spacecraft in space?

10. Why is the sun not shown in this graphic?

11. Write a paragraph describing the trajectory of the Genesis spacecraft.