

FYI

Studying Planets and Moons Through Space Missions

Our explorations of the planets and moons in the solar system are no longer limited to what can be seen through a telescope. Since the 1960s, we've been sending out different spacecraft—flybys, orbiters, landers, rovers, and even human crews—on missions for close-up observation.

Flybys

A **flyby** is the flight of a spacecraft past a celestial body, such as a planet, from close enough to obtain scientific data. Flyby also refers to the spacecraft that makes such a flight.

The first successful mission to a world other than Earth was *Luna 1*, sent to the moon by the Russians. *Luna 1*, which was intended to crash into the moon's surface, instead acted as a flyby. It passed within 5,995 kilometers of the moon's surface on January 4, 1959.

Other flybys followed. For example, *Mariner 4*, sent by the United States, was the first successful flyby of Mars. After seven and a half months of flight, the spacecraft flew by Mars on July 14 and 15, 1965. It took the first pictures of the Martian surface—indeed, the first pictures of another planet—ever returned from deep space. At its closest, *Mariner 4* was 9,846 km from the Martian surface.

The outer planets were visited by flyby missions *Voyagers 1* and *2*, launched by the United States in 1977. *Voyager 1* flew by Jupiter in 1979 and Saturn in 1980. *Voyager 2* flew by Jupiter in 1979 and Saturn in 1981, then continued on, flying by Uranus in 1986 and Neptune in 1989. Both spacecraft continue their flights, having passed well beyond the orbit of Pluto. As of July 2009, *Voyager 1* was at a distance of 16.5 billion kilometers, or 110 AU, from the sun, making it farther from Earth than any other human-made object.

In general, flybys are cheaper and easier to accomplish than other types of missions, and they can visit more than one planet or moon. However, they have only a limited amount of time to observe each world, and those observations are made from a distance.



Figure 3-6: Drawing of a flyby spacecraft

Orbiters

An **orbiter** is a spacecraft that orbits a celestial body, such as a planet or moon, to obtain scientific data.

The first orbiter of a world other than Earth was *Lunar Orbiter 1*, which orbited the moon in 1966, collecting data about the moon's surface. More orbiters followed. For example, the *Mars Global Surveyor*, which was launched in 1996, began orbiting Mars in 1997. It orbited Mars at an average altitude—height above the surface—of about 378 kilometers. It orbited from pole to pole, so over time, it got magnificent photographs of the entire Martian surface.

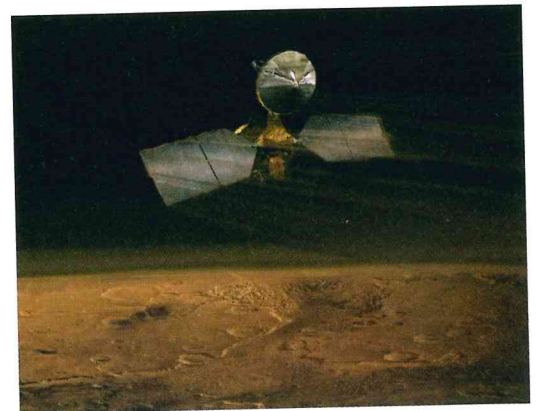


Figure 3-7: Drawing of an orbiter

An orbiter provides long-term observations of its world, but it is, in general, more expensive and technically difficult to deploy than a flyby, and still only supplies remote observations—observations made from a distance.

Landers

A **lander** is a spacecraft that lands on a celestial body, such as the moon or a planet, to obtain scientific data.

The Russian spacecraft *Luna 2* was the first lander, of a sort, though it is more accurately considered the first impact. It crashed into the surface of the moon in 1959. *Luna 9* was the first spacecraft to actually land, as opposed to crash, on another world. It landed on the moon on February 3, 1966 and sent photographs back to Earth. *Venera 7* was the first successful landing of a spacecraft on another planet. It entered the atmosphere and then landed on the surface of Venus on December 15, 1970. Other landers followed, including *Viking 1 and 2*, which carried experiments related to the search for life on Mars. Landers such as *Luna 16* may involve a sample return—the sending back of materials from that world to Earth.

A lander can take much more complete observations of its world and may enable a sample return, but the mission is more expensive and more complex than flybys and orbiters. In addition, it can observe only a limited area immediately around the landing spot.

Rovers

A **rover** is a vehicle that explores the surface of a moon or planet.

The first rovers were used on the moon. *Lunokhod 1*, which means “moon walker” in Russian, was the first of two unmanned lunar rovers that landed on the moon. The rovers, which were remote controlled, operated for about eleven months in 1970 and 1971, traveled about 10,540 meters on the moon's surface, transmitted over twenty thousand images, and conducted hundreds of tests of the moon's soil. In

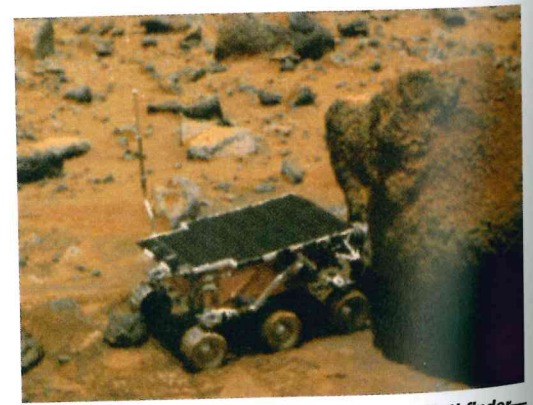


Figure 3-8: Photograph of a rover—the Mars Pathfinder—on Mars

1971, a manned vehicle was used by the astronauts of *Apollo 15*, *16*, and *17*. (See below under Human Spaceflight for more on the *Apollo* missions.) This rover greatly extended how far the astronauts could explore.

The *Mars Pathfinder*, which landed on Mars on the Fourth of July 1997, carried the first robotic rover to explore another planet. Named *Sojourner*, after the famous American abolitionist Sojourner Truth, the rover explored the planet for almost three months, taking hundreds of images and analyzing the rock and soil at 16 locations around the lander. *Sojourner* was followed in 2003 by *Spirit* and *Opportunity*, which were still operating in 2009.

Rovers increase the complexity of a lander mission, but they are able to gather data in a larger area of a world's surface than the lander can.

Human Spaceflight

A **human spaceflight mission** is one that involves human beings. During the 1960s and 1970s, the United States ran the *Apollo* space program, which involved a series of missions related to landing a human being on the moon. *Apollo 8* was the second human spaceflight mission of the program, and the three astronauts onboard became the first humans to leave Earth's orbit and to orbit around the moon. *Apollo 11*, the fifth human spaceflight mission of the *Apollo* space program, was the first time a human being set foot on a world other than Earth. Neil Armstrong and Edwin 'Buzz' Aldrin stepped onto the surface of the moon on July 20, 1969. To date, they were the first of just twelve to do so.

Human beings are able react, make decisions, and do things that can make them an asset to a mission; however, it is undeniably costly, dangerous, and technologically challenging to send human beings into space, let alone to other worlds.



Checking In

1. Which planets in our solar system have we gone to with some kind of mission?
2. What kinds of information can be gained from different types of missions?

