



Apollo 13: “A Successful Failure”

After the historic Apollo 11 and Apollo 12 Moon missions, NASA planned more adventurous visits to different geological zones on the lunar surface. Apollo 13 sought to explore the Fra Mauro Highlands, an area excavated by the Imbrium impact crater.

However, an accident that occurred midway on the flight to the Moon eliminated any chance for a lunar landing and for a time appeared to threaten the very survival of the crew. The story captivated the world.

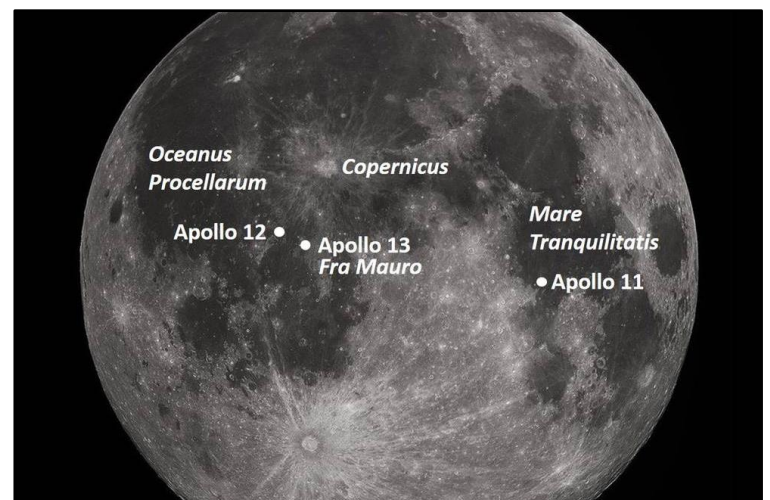
Through a combination of equipment redundancy, extensive simulation and in-flight innovation, the brave and talented crew was able to use its Lunar Module as a “lifeboat” until reentry and a successful splashdown. The mission was a “successful failure.”



All photos courtesy of NASA unless otherwise noted.

Major Mission Objectives:

- Land in the Fra Mauro Highlands.
- Conduct two four-hour Moon walks.
- Deploy a new nuclear-powered seismometer to measure “moon quakes,” an improvement on the earlier solar-powered units.
- Set up a heat flow experiment and a device to measure Solar protons and electrons.
- Photograph candidate future landing sites.





From left to right: Lovell, Swigert, and Haise.

Launch and Flight

On April 11, 1970, Apollo 13 launched from Launch Complex 39A at Cape Kennedy (later renamed Cape Canaveral), Florida. The first stage performed normally for the first two-and-a-half minutes of the flight. However, the center engine of the Saturn V's second stage unexpectedly shut down two minutes early, making it necessary to let the remaining four engines burn longer to propel the spacecraft into Earth orbit.

Shortly after leaving Earth orbit, the Command and Service module Odyssey detached, pulled forward, turned around and extracted the Lunar Module Aquarius from its adapter atop the Saturn V.

For the first time, and in order to land at Fra Mauro, the flight plan to the Moon was not a “free-return” trajectory, the type that would have put the spacecraft on a path to whip around the Moon and return it to Earth orbit if there was a problem.

The Crew

The Apollo 13 astronaut crew was composed of one veteran NASA astronaut and two rookies. Commander Jim Lovell had previously flown on Gemini 7 and 12 and was part of the Apollo 8 crew that first orbited the Moon in December 1968. Joining him were Command Module Pilot Jack Swigert and Lunar Module Pilot Fred Haise. Swigert, originally on the Apollo 13 backup crew, was a late replacement for Ken Mattingly, who was exposed to measles shortly before the flight.

Apollo 13 would be the final space flight for all of these astronauts.



Instead, a mid-course engine burn put Apollo 13 on a path that would still swing around the Moon but miss the Earth by 40,000 miles on the trip back.

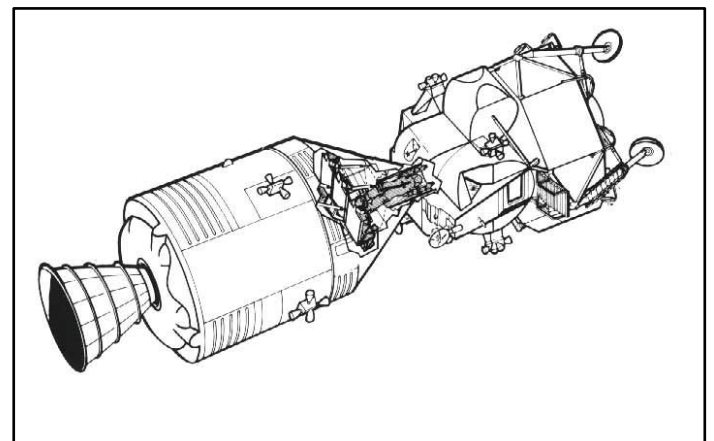
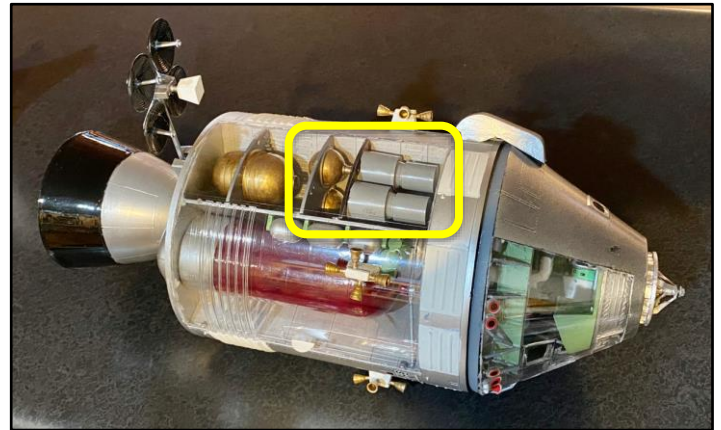
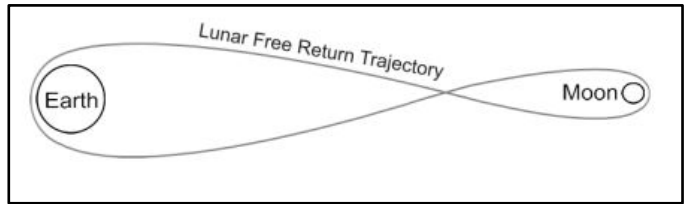
The flight proceeded smoothly until shortly after a television broadcast by the crew, 56 hours into the flight and 210,000 miles from Earth. Jack Swigert complied with a request by Mission Control to redistribute the ultra-cold slushy liquid hydrogen and oxygen in the fuel tanks of the Service Module (gold tanks in photo inset).

Command Module model photo courtesy Dan Hoy.

Upon flipping the fan switches (see control panel inset) for this “cryo stir,” the crew heard a loud bang and felt a shudder in their spacecraft. Immediately, alarms, warning lights, data feeds and power and fuel gauges indicated serious issues. Lovell radioed to Mission Control the infamous, “Houston, we’ve had a problem.”

Problem, indeed. Eventually, both oxygen tank levels dropped to zero and the fuel cells powering the Command Module fell to zero or were shut down. As the spacecraft continued to die, the crew quickly shut it down, moved into the Lunar Module and used it as their “lifeboat” for the majority of their trip. The Moon lander, designed for a crew of two for just a few days, now had to propel, aim and sustain the three.

Once the fuel cells were shut down, mission rules called for cancellation of the landing, so the crew had only to concern themselves with returning safely to Earth. After exploring several options, it was decided to use the Lunar Module’s descent engine to continue toward the Moon, using lunar gravity to sling the two joined spacecraft on a path back to Earth orbit.

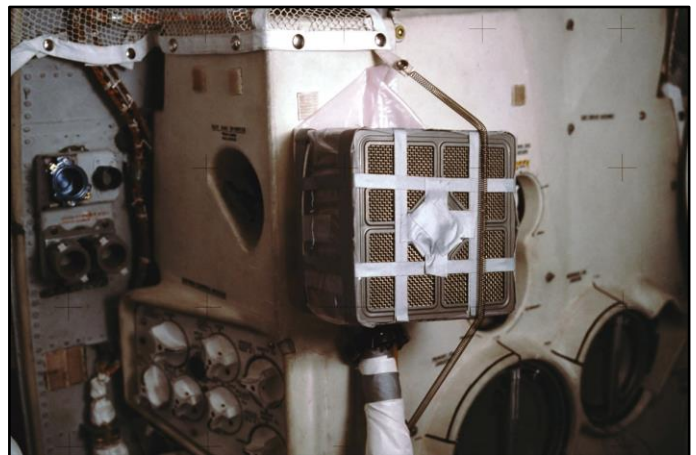


Because the Lunar Module would not be using its oxygen fuel to land on or launch from the Moon, oxygen to breathe was not an issue. However, water and power needed to be rationed carefully. With meager power use, the two joined craft eventually cooled down to almost freezing. The crew's moist breath condensed on and behind the electrical control panels, and the carbon dioxide they exhaled poisoned their breathing air. Ingeniously, engineers at Mission Control were able to tell the crew how to use various items to cobble together a way to use the Command Module's round lithium hydroxide canisters in the Lunar Module's square holder. This soon made the air safe to breathe.

The stress of the situation, the cramped quarters of the Lunar Module, the cold temperatures and the noise of spacecraft systems and radio communications made it difficult for the crew to sleep. Yet, they were able to work with Mission Control to execute their tasks successfully. Defying the challenges, the Lunar Module and crew performed well, putting them on course to return to Earth on April 17, a little over three days after the fateful accident.

As they neared Earth orbit, the crew powered up the Command Module and then jettisoned the Service Module. As they did so, they photographed the catastrophic damage, noting that a whole panel had been blown away from the segment that housed the oxygen tanks. Finally, the Lunar Module Aquarius was released, and the crew prepared to land.

On April 17, after a long, nail-biting radio silence during reentry, Apollo 13's parachutes opened successfully and splashdown occurred at 1:07 pm EST.



Mission Insights

After the Apollo 13 mission ended, an extensive investigation into the explosion was conducted. Investigators learned that the accident resulted from a series of mistakes that occurred over several years.

First, the oxygen tanks used in Apollo 13 had originally been installed in Apollo 10 and had been removed to make room for an improved design. During that process, one mounting bolt was not removed, and as a result, the tank was dropped a short distance, perhaps dislodging its drain tube.

Furthermore, when the tank electronics were modified to work at 65 volts, a thermostat designed to work at 28 volts was left in place. This made it vulnerable to fusing during ground tests.

Finally, in a ground test before the flight, the tank's abnormal drain tube resulted in a decision to use its heater to boil off its oxygen. This process fused the thermostat and damaged insulation on the tank wiring. Later, during the mission, when the oxygen tank fans were switched on, a spark caused the liquid oxygen-filled tank to explode.

With improvements made as a result of the investigation, Apollo 14 launched for the Fra Mauro Highlands on January 31, 1971.

The Apollo 13 Command Module Odyssey is now displayed in The Cosmosphere in Hutchinson, Kansas. It is one of more than 300 science museums you can visit admission-free with a Science Center of Iowa membership!

Photo courtesy of The Cosmosphere

For more information see: <https://nasasearch.nasa.gov/search?query=Apollo+13&affiliate=nasa&utf8=%E2%9C%93>

