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#### SURVEYOR IV MISSION

The mission of Surveyor IV ended in failure on July 16, 1967, just 2 1/2 minutes before the spacecraft was to land on the moon.

Radio signal from the spacecraft cut off abruptly at 7:02:35 p.m. Pacific Daylight Time just seconds before burnout of Surveyor's main retro engine.

Mission operations continued for two days in an attempt to re-establish communications with the spacecraft, but all efforts failed. Cause of the mishap was unknown, and it remains undetermined whether Surveyor IV achieved a soft landing during radio silence.

Surveyor IV was to land in Sinus Medii (Central Bay) near the exact center of the moon, as seen from Earth, a few miles from the aiming point of Surveyor II, which failed in September, 1966, during execution of a mid-course maneuver. The fourth Surveyor was to repeat the performances of Surveyor I and Surveyor III which transmitted to Earth a combined 17,465 TV pictures and, in the latter mission, dug and picked the moon's surface with a surface sampling instrument.

Three more Surveyors are planned for 1967-68. They are built for the National Aeronautics and Space Administration by Hughes Aircraft Company under contract to the Jet Propulsion Laboratory.

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JPL is responsible to NASA for Surveyor Project management.

Until the final few minutes of flight, the Surveyor IV mission had proceeded normally. The spacecraft was launched by an Atlas-Centaur rocket combination from Cape Kennedy, Florida, at 4:53:29 a.m. PDT on July 14. ( Launch was postponed from the previous day because of a minor launch vehicle problem.)

Guidance by the launch vehicle alone was accurate enough to put Surveyor IV on the moon within 93 miles of the aiming point. This accuracy allowed project officials to delay the mid-course trajectory correction until liftoff plus 39 hours for a more effective mid-course maneuver.

The maneuver was executed perfectly on July 15. After a  $+72.5^{\circ}$  roll turn and a  $-64.3$  yaw turn, Surveyor's three vernier rocket engines fired at 7:30 p.m. PDT for a duration of 10.475 seconds, changing spacecraft velocity by about 20 miles per hour and shortening time of flight by about 30 minutes.

Tracking data following the maneuver indicated Surveyor IV would land within about 2 1/2 miles of the aiming point --  $1^{\circ} 20'$  West Longitude and 25' north of the lunar equator -- at 7:05:05 p.m. PDT July 16.

Terminal maneuver began at 6:23 p.m. July 16 with three spacecraft turns: Roll +  $80.63^{\circ}$  , Yaw +  $92.85^{\circ}$  and Roll -  $24.76^{\circ}$ .

At 7:01:05 p.m., touchdown was exactly four minutes away, spacecraft approach velocity had reached 5839 miles per hour and the Altitude Marking Radar (AMR) sent a signal to Surveyor's flight control system which would start the retro sequence within a minute.

The three vernier engines ignited at 7:01:54 p.m. One second later, the 10,000-pound-thrust main retro motor ignited and the spacecraft rapidly decelerated. The large solid propellant engine was to fire for 42 seconds and slow the spacecraft to about 300 miles per hour at some 35,000 feet altitude.

At 7:02:35, just two seconds before main retro burnout was expected, the command center at JPL in Pasadena, Calif., reported loss of Surveyor's radio signal. The Deep Space Network's Goldstone Station in the Mojave Desert about 200 miles from JPL, which had been commanding the terminal sequence and receiving telemetry from Surveyor, reported that the signal had quit abruptly.

Emergency procedures were implemented with numerous combinations of commands being transmitted to the spacecraft to re-establish the communications link. Surveyor's redundancy features and the proper series of commands would allow recovery of the signal in the event of failure in a single unit in the telecommunications system, such as one of the transmitters or antennas.

Commanding continued until the end of the Goldstone viewing period at 1:09 a.m. PDT July 17 and was resumed about 14 hours later while receivers at Goldstone and at the DSN station at Canberra, Australia, searched in vain for a response from the spacecraft. When no signal was received by July 18, the Surveyor IV mission was concluded.

Thought at first to be the most probable cause of failure was an explosion in the main retro motor during the final seconds of retro fire. However, a team of engineers which studied the mission failure listed four possible causes but did not pinpoint any one cause as more probable than the others.

They reported that the communications loss could have resulted from:

-- The breakage of a critical power lead in a wiring harness or the failure of a connector or solder joint.

-- Rupture of the main retro motor case, resulting in damage to spacecraft circuitry.

-- A transmitter failure, causing power to drop to a point which would have prevented transmissions over the 238,857 miles from moon to Earth.

-- Rupture of a pressure vessel such as a helium or nitrogen tank, a shock absorber or a propellant tank, which would result in damage or cutting of electrical circuits.

The team did not preclude the possibility that Surveyor IV, although not in radio contact with Earth, did land itself on the moon.

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