65)
Luna 9
Nation: USSR (40)
Objective(s): lunar soft-landing
Spacecraft: Ye-6M (no. 202)
Spacecraft Mass: 1,538 kg
Mission Design and Management: GSMZ Lavochkin
Launch Vehicle: 8K78M (no. U103-32)
Launch Date and Time: 31 January 1966 / 11:41:37 UT
Launch Site: NIIP-5 / launch site 31
Scientific Instruments:
1) imaging system
2) SBM-10 radiation detector
Results: With this mission, the Soviets accomplished another spectacular first in the space race, the first survivable landing of a human-made object on another celestial body. Luna 9 was the twelfth attempt at a soft-landing by the Soviets; it was also the first deep space probe built by the Lavochkin design bureau, which ultimately would design and build almost all Soviet (and Russian) lunar and interplanetary spacecraft. All operations prior to landing occurred without fault, and the 58-centimeter spheroid ALS capsule landed on the Moon at 18:45:30 UT on 3 February 1966 west of the Reiner and Marius craters in the Ocean of Storms (at 7°8' north latitude and 64°22' west longitude). Approximately 5 minutes after touchdown, Luna 9 began transmitting data to Earth, but it was 7 hours (after the Sun climbed to 7° elevation) before the probe began sending the first of nine images (including five panoramas) of the surface of the Moon. These were the first images sent from the surface of another planetary body. The radiation detector, the only scientific instrument on board, measured a dosage of 30 millirads per day. Perhaps the most important discovery of the mission was determining that a foreign object would not simply sink into the lunar dust, that is, that the ground could support a heavy lander. Last contact with the spacecraft was at 22:55 UT on 6 February 1966.

66)
Kosmos 111 / [Luna]
Nation: USSR (41)
Objective(s): lunar orbit
Spacecraft: Ye-6S (no. 204)
Spacecraft Mass: c. 1,580 kg
Mission Design and Management: GSMZ Lavochkin
Launch Vehicle: 8K78M (no. N103-41)
Launch Date and Time: 1 March 1966 / 11:03:49 UT
Launch Site: NIIP-5 / launch site 31
Scientific Instruments:
1) magnetometer
2) gamma-ray spectrometer
3) five gas-discharge counters

4) two ion traps and a charged-particle trap
5) piezoelectric micrometer detector
6) infrared detector
7) low-energy x-ray photon counters

Results: In early 1966, the Soviets began hastily putting together an interim lunar orbiter program, the Ye-6S, partly to upstage the American Lunar Orbiter project and partly to commemorate the 23rd Congress of the Communist Party held in March 1966. Engineers quickly designed a set of two rudimentary probes using the old Ye-6 (lander) buses for these missions. The first of them was prepared in less than a month but failed to leave Earth orbit. During Earth orbit operations, the Blok L upper stage lost roll control and failed to fire to send the probe towards the Moon. The official Soviet media named the stranded satellite Kosmos 111; it reentered Earth's atmosphere two days after launch.

67)
Luna 10
Nation: USSR (42)
Objective(s): lunar orbit
Spacecraft: Ye-6S (no. 206)
Spacecraft Mass: 1,582 kg
Mission Design and Management: GSMZ Lavochkin
Launch Vehicle: 8K78M (no. N103-42)
Launch Date and Time: 31 March 1966 / 10:47 UT
Launch Site: NIIP-5 / launch site 31
Scientific Instruments:
1) magnetometer
2) gamma-ray spectrometer
3) five gas-discharge counters
4) two ion traps and a charged-particle trap
5) piezoelectric micrometer detector
6) infrared detector
7) low-energy x-ray photon counters

Results: After a midcourse correction on 1 April, Luna 10, the second of two hastily prepared Soviet Ye-6S probes (that is, the backup), successfully entered lunar orbit two days later at 18:44 UT, thus becoming the first humanmade object to go into orbit around another planetary body. A 245-kilogram instrument compartment separated from the main bus, which was in a 350 x 1,000-kilometer orbit inclined at 71.9° to the lunar equator. The spacecraft carried a set of solid-state oscillators that had been programmed to reproduce the notes of the Internationale so that it could be broadcast live to the 23rd Communist Party Congress. During a rehearsal on the night of 3 April, the playback went well, but the following morning, controllers discovered a missing note and played the previous night's tape to the assembled gathering at the Congress–claiming it was a live broadcast from the Moon. Luna 10 conducted extensive research in lunar orbit, gathering important data on the weakness of the Moon's magnetic field, its radiation belts, and the nature of lunar rocks (which were found to be comparable to terrestrial basalt rocks), cosmic radiation, and micrometeoroid density. Perhaps its most important finding was the first evidence of mass concentrations (called "mascons")—areas of high density below the mare basins that distort lunar orbital trajectories. Their discovery has usually been credited to the American Lunar Orbiter series. Last contact was on 30 May 1966.

68)
Surveyor Model 2
Nation: U.S. (26)
Objective(s): highly elliptical orbit
Spacecraft: SD-3
Spacecraft Mass: 784 kg
Mission Design and Management: NASA JPL
Launch Vehicle: Atlas-Centaur (AC-8 / Atlas no. 184D / Centaur D)
Launch Date and Time: 8 April 1966 / 01:00:02 UT
Launch Site: ETR / launch complex 36B
Scientific Instruments: none
Results: This was a test to launch a dummy Surveyor lunar lander spacecraft into a barycentric orbit toward a simulated Moon. Unlike the two previous Surveyor mass model tests, this flight was supposed to demonstrate a restart capability for the Centaur upper stage. The Centaur-Surveyor combination successfully achieved parking orbit around Earth, but at the desired time, the Centaur engines fired for only a few seconds. A thrust imbalance left the payload tumbling. The problem was later traced to a hydrogen peroxide leak in the ullage motors of the Centaur stage. With no hope of reaching its ultimate

orbit, the spacecraft reentered Earth's atmosphere on 5 May 1966.

69)
Surveyor 1
Nation: U.S. (27)
Objective(s): lunar soft-landing
Spacecraft: Surveyor-A
Spacecraft Mass: 995.2 kg
Mission Design and Management: NASA JPL
Launch Vehicle: Atlas-Centaur (AC-10 / Atlas D no. 290 / Centaur D)
Launch Date and Time: 30 May 1966 / 14:41:01 UT
Launch Site: ETR, launch complex 36A
Scientific Instruments:

1) imaging system

Results: NASA initially (c. 1963) conceived of the Surveyor program as a landing and orbiting robotic lunar project, but it scaled down plans to a more specific program of ten lunar soft-landers (seven were eventually launched) geared toward basic engineering goals rather than scientific exploration. The primary "scientific instrument" was an imaging system. Unlike the Soviet Luna landers, Surveyor was a true soft-lander, comprising a 3-meter-tall vehicle based on a 27-kilogram, thin-walled aluminum triangular structure with one of three legs at each corner and a large solid-propellant retrorocket engine (that comprised over 60 percent of the spacecraft's overall mass) in the center. The spacecraft was equipped with a Doppler velocity-sensing system that fed information into the spacecraft computer to implement a controllable descent to the surface. Each of the three landing pads also carried aircraft-type shock absorbers and strain gauges to provide data on landing characteristics, important for future Apollo missions. Surveyor 1, the first in the series, was an unprecedented success. NASA accomplished the first true soft-landing on the Moon on its very first try when the probe landed in the southwest region of the Ocean of Storms at 06:17:36 UT on 2 June 1966, just 63.6 hours after launch from Cape Canaveral. Touchdown coordinates were 2°27' south latitude and 43°13' west longitude, just 14 kilometers from the planned target. At landing, the spacecraft weighed 294.3 kilograms. The initial panoramic views from the lunar surface indicated that Surveyor 1 was resting in a 100-kilometer-diameter crater that contained boulders of more than 1 meter in length scattered all around. The photos showed crestlines of low mountains in the distant horizon. The lander transmitted 11,350 images over two separate communications sessions by 6 July. Although the primary mission was completed by 13 July, NASA maintained contact until 7 January 1967. Without doubt, Surveyor 1 was one of the great successes of NASA's early lunar and interplanetary program.

Image of Surveyor 1's shadow against the lunar surface in the late lunar afternoon, with the horizon at the upper right. Surveyor 1 was the first U.S. mission to make a successful soft-landing on the Moon. In addition to transmitting over 11,000 pictures, it sent information on the bearing strength of the lunar soil, the radar reflectivity, and temperature.

70)

Explorer 33

Nation: U.S. (28)
Objective(s): lunar orbit
Spacecraft: IMP-D
Spacecraft Mass: 93.4 kg
Mission Design and Management: NASA GSFC
Launch Vehicle: Thor-Delta E-1 (no. 39 / Thor no. 467 / DSV-3E)
Launch Date and Time: 1 July 1966 / 16:02:25 UT
Launch Site: ETR / launch complex 17A
Scientific Instruments :

1) fluxgate magnetometers
2) thermal ion probe
3) ion chamber
4) tubes plus p-on-n junction
5) Faraday-cup probe

Results: Explorer 33 was designed to become the first U.S. spacecraft to enter lunar orbit (planned parameters were 1,300 x 6,440 kilometers at 175° inclination), but the Thor Delta E-1 second stage accelerated too rapidly for compensation by the probe's retrorocket to achieve lunar orbit. Instead, the spacecraft (56.7 kg by this time) went into an eccentric Earth orbit of 15,897 x 435,330 kilometers. The main solid-propellant retrorocket engine later stabilized the orbit to a less eccentric 30,550 x 449,174-kilometer orbit at 28.9° inclination. In its new orbit, the probe returned key data on Earth's magnetic tail, the interplanetary magnetic field, and radiation.

71)

Lunar Orbiter 1

Nation: U.S. (29)
Objective(s): lunar orbit
Spacecraft: LO-A
Spacecraft Mass: 385.6 kg
Mission Design and Management: NASA LaRC
Launch Vehicle: Atlas-Agena D (no. 17 / Atlas D no. 5801 / Agena D no. AD121 / 6630)
Launch Date and Time: 10 August 1966 / 19:26:00 UT
Launch Site: ETR / launch complex 13
Scientific Instruments:

1) imaging system
2) micrometeoroid detectors
3) radiation dosimeters

Results: The Lunar Orbiter program originated as a response to the need to obtain 1-meter-resolution photographs of potential Apollo landing sites. NASA planned launches of a series of three-axis stabilized spacecraft with four solar panels and a main engine (derived from an Apollo attitude control thruster) for lunar orbit insertion. The primary instrument on board was a 68-kilogram Eastman-Kodak imaging system (using wide- and narrow-angle lenses) that could develop exposed film, scan the images, and send them back to Earth. The narrow-angle pictures provided resolution of up to 60 to 80 meters, while the wide-angle photos showed resolutions up to 0.5 kilometers. Lunar Orbiter 1 entered a 191 x 1,854-kilometer orbit around the Moon on 24 August, becoming the first U.S. spacecraft to do so. The spacecraft's primary mission was to photograph nine potential Apollo landing sites, seven secondary areas, and the Surveyor 1 landing site. During its mission, the probe took 207 frames of the lunar surface covering an area of 5.18 million square kilometers. The high-resolution photos were blurred from smearing, but the medium-resolution images were the best lunar surface images returned to date. One of the images returned, taken on 23 August, was the first picture of Earth from the Moon. Lunar Orbiter 1 returned its last picture on 30 August and was commanded to crash on to the lunar surface on 29 October to prevent its transmissions from interfering with future Lunar Orbiters. Impact coordinates were 6°42' north latitude and 162° east longitude (at 13:30 UT).

72)

Pioneer 7

Nation: U.S. (30)
Objective(s): heliocentric orbit
Spacecraft: Pioneer-B
Spacecraft Mass: 62.75 kg
Mission Design and Management: NASA ARC
Launch Vehicle: Thor-Delta E-1 (no. 40 / Thor no. 462 / DSV-3E)
Launch Date and Time: 17 August 1966 / 15:20:17 UT
Launch Site: ETR / launch complex 17A
Scientific Instruments:

1) single-axis fluxgate magnetometer
2) Faraday-cup plasma probe
3) plasma analyzer
4) cosmic-ray telescope
5) cosmic-ray-anisotropy detector

6) radio wave propagation experiment
7) celestial mechanics experiment

Results: Identical to Pioneer 6, Pioneer 7 was put into heliocentric orbit at 0.814 x 0.985 AU to study the solar magnetic field, the solar wind, and cosmic rays at widely separated points in solar orbit. On 7 September 1968, the spacecraft was correctly aligned with the Sun and Earth to begin studying Earth's magnetic tail. In 1977, eleven years after its launch, Pioneer 7 registered the magnetic tail 19.3 million kilometers out, three times further into space than recorded previously. On 20 March 1986, the spacecraft flew within 12.3 million kilometers of Halley's Comet and monitored the interaction between the cometary hydrogen tail and the solar wind. As with Pioneer 6 and Pioneer 8, NASA continues to maintain intermittent contact with Pioneer 7, more than thirty years after its mission began. On 31 March 1995, for example, the plasma analyzer was turned on during 2 hours of contact with the ground.

73)
Luna 11
Nation: USSR (43)
Objective(s): lunar orbit
Spacecraft: Ye-6LF (no. 101)
Spacecraft Mass: 1,640 kg
Mission Design and Management: GSMZ Lavochkin
Launch Vehicle: 8K78M (no. N103-43)
Launch Date and Time: 24 August 1966 / 08:03 UT
Launch Site: NIIP-5
Scientific Instruments:
1) imaging system
2) gamma-ray detector
3) magnetometer
4) radiation detectors
5) infrared radiometer
6) meteoroid detectors
7) R-1 gear transmission experiment

Results: This subset of the "second-generation" Luna spacecraft, the Ye-6LF, was designed to take the first photographs of the surface of the Moon from lunar orbit. A secondary objective was to obtain data on mass concentrations ("mascons") on the Moon first detected by Luna 10. Using the basic Ye-6 bus, a suite of scientific instruments (plus an imaging system similar to the one used on Zond 3) replaced the small lander capsule used on the soft-landing flights. The resolution of the photos was reportedly 15 to 20 meters. A technological experiment included testing the efficiency of gear transmission in vacuum as a test for a future lunar rover. Luna 11, launched only two weeks after the U.S. Lunar Orbiter, successfully entered lunar orbit at 21:49 UT on 27 August. Parameters were 160 x 1,193 kilometers. During the mission, the TV camera failed to return usable images because the spacecraft lost proper orientation to face the lunar surface when a foreign object was lodged in the nozzle of one of the attitude-control thrusters. The other instruments functioned without fault before the mission formally ended on 1 October 1966 after the power supply had been depleted.

74)
Surveyor 2
Nation: U.S. (31)
Objective(s): lunar soft-landing
Spacecraft: Surveyor-B
Spacecraft Mass: 995.2 kg
Mission Design and Management: NASA JPL
Launch Vehicle: Atlas-Centaur (AC-7 / Atlas D no. 194 / Centaur D)
Launch Date and Time: 20 September 1966 / 12:32:00 UT
Launch Site: ETR / launch complex 36A
Scientific Instruments:
1) imaging system

Results: Surveyor 2, similar in design to its predecessor, was aimed for a lunar soft-landing in Sinus Medii. During the coast to the Moon, at 05:00 UT on 21 September, one of three thrusters failed to ignite for a 9.8-second midcourse correction and thus put the spacecraft into an unwanted spin. Despite as many as thirty-nine repeated attempts to fire the recalcitrant thruster, the engine failed to ignite, and Surveyor 2 headed to the Moon without proper control. Just 30 seconds after retro-fire ignition at 09:34 UT on 22 September, communications fell out, and the lander crashed on to the surface of the Moon at 5°30' north latitude and 12° west longitude, just southeast of Copernicus crater.

75)
Luna 12
Nation: USSR (44)
Objective(s): lunar orbit
Spacecraft: Ye-6LF (no. 102)
Spacecraft Mass: 1,620 kg
Mission Design and Management: GSMZ Lavochkin
Launch Vehicle: 8K78M (no. N103-44)
Launch Date and Time: 22 October 1966 / 08:42 UT
Launch Site: NIIP-5 / launch site 31
Scientific Instruments:
1) imaging system
2) gamma-ray detector
3) magnetometer
4) radiation detectors
5) infrared radiometer
6) meteoroid detectors
7) R-1 gear transmission experiment

Results: Luna 12 was launched to complete the mission that Luna 11 had failed to accomplish—take high-resolution photos of the Moon's surface from lunar orbit. Luna 12 successfully reached the Moon on 25 October 1966 and entered a 133 x 1,200-kilometer orbit. The Soviet press released the first photos taken of the surface on 29 October—pictures that showed the Sea of Rains and the Aristarchus crater. Resolution was as high as 15 to 20 meters. Film was developed, fixed, dried automatically, and scanned for transmission to Earth. No further photos were ever released. After completing its main imaging mission, Luna 12 was put into a spin-stabilized roll to carry out its scientific mission, which was fulfilled quite successfully. Contact was finally lost on 19 January 1967 after 302 communications sessions.

76)
Lunar Orbiter 2
Nation: U.S. (32)
Objective(s): lunar orbit
Spacecraft: LO-B
Spacecraft Mass: 385.6 kg
Mission Design and Management: NASA LaRC
Launch Vehicle: Atlas-Agena D (no. 18 / Atlas D no. 5802 / Agena D no. AD122 / 6631)
Launch Date and Time: 6 November 1966 / 23:21:00 UT
Launch Site: ETR / launch complex 13
Scientific Instruments:
1) imaging system
2) micrometeoroid detectors
3) radiation dosimeters

Results: Lunar Orbiter 2's mission was to photograph thirteen primary and seventeen secondary landings sites for the Apollo program in the northern region of the Moon's near side equatorial area. On 10 November 1966, the spacecraft entered a 196 x 1,871-kilometer orbit around the Moon. By 6 December, when the probe transmitted back its last photograph, 211 pictures had been taken of both the near side and large areas of the far side. These photos covered nearly four million square kilometers of the lunar surface. The high-gain transmitter failed on the same day, but did not significantly affect the coverage afforded by the photos. Lunar Orbiter 2 returned perhaps the most memorable photo of any in the series, a spectacular shot looking across the Copernicus crater from an altitude of only 45 kilometers, which vividly emphasized the three-dimensional nature of the lunar surface. On 8 December, after the main photographic mission was over, Lunar Orbiter 2 fired its main engine to change its orbital plane in order to provide tracking data of the Moon's gravitational field over a wider swath. Finally, on 11 October 1967, when attitude control gas was almost depleted, a retro-burn deliberately crashed the spacecraft onto the lunar surface at 4° south latitude and 98° east longitude on the far side to prevent communications interference on future missions.

77)
Luna 13
Nation: USSR (45)
Objective(s): lunar soft-landing
Spacecraft: Ye-6M (no. 205)
Spacecraft Mass: 1,620 kg
Mission Design and Management: GSMZ Lavochkin
Launch Vehicle: 8K78M (no. N103-45)
Launch Date and Time: 21 December 1966 / 10:17 UT
Launch Site: NIIP-5 / launch site 1
Scientific Instruments:
1) TV cameras
2) infrared radiometer
3) penetrometer

4) radiation densitometer
5) radiation detector

Results: Luna 13 became the second Soviet spacecraft to successfully soft-land on the surface of the Moon. The probe landed in the Ocean of Storms at 18:01 UT on 24 December 1966, between the Krafft and Seleucus craters at 18°52' north latitude and 62°3' west longitude. Unlike its predecessor, the heavier Luna 13 lander (113 kilograms) carried a suite of scientific instruments in addition to the usual imaging system. A three-axis accelerometer within the pressurized frame of the lander recorded the landing forces during impact to determine the soil structure down to a depth of 20 to 30 centimeters. A pair of spring-loaded booms was also deployed. Both were equipped with titanium-tipped rods that were driven into the ground with a powerful force by small explosive charges to measure soil density (found at roughly 0.8 grams per cubic centimeter). Four radiometers recorded infrared radiation from the surface indicating a noon temperature of 117 ± 3°C while a radiation detector indicated that radiation levels would be less than hazardous for humans. The lander returned a total of five panoramas of the lunar surface, showing a more smooth terrain than seen by Luna 9. One of the two cameras (intended to return stereo images) failed, but this did not diminish the quality of the photographs. After a fully successful mission, contact was lost at 06:13 UT on 28 December when the onboard batteries were exhausted.