137)

**Luna 21**

**Nation:** USSR (85)
**Objective(s):** lunar roving operations
**Spacecraft:** Ye-8 (no. 204)
**Spacecraft Mass:** c. 5,950 kg
**Mission Design and Management:** GSMZ Lavochkin
**Launch Vehicle:** 8K82K + Blok D (Proton-K no. 259-01)
**Launch Date and Time:** 8 January 1973 / 06:55:38 UT
**Launch Site:** NIIP-5 / launch site 81L
Scientific Instruments:

1) imaging system (three low-resolution TVs and four high-resolution photometers)
2) x-ray spectrometer
3) penetrometer
4) laser reflector
5) radiation detectors
6) x-ray telescope
7) odometer/speedometer
8) visible/ultraviolet photometer
9) magnetometer
10) photodetector

**Results:** Luna 21 carried the second successful Soviet "8YeL" lunar rover, Lunokhod 2, and was launched less than a month after the last Apollo lunar landing. After a midcourse correction the day after launch, Luna 21 entered orbit around the Moon on 12 January 1973. Parameters were 100 x 90 kilometers at 60° inclination. On 15 January, the spacecraft deorbited and, after multiple engine firings, landed on the Moon at 22:35 UT the same day, inside the LeMonnier crater at 25°51' north latitude and 30°27' east longitude, between Mare Serenitatis and the Taurus Mountains. Less than 3 hours later, at 01:14 UT on 16 January, the rover disembarked onto the lunar surface. The 840-kilogram Lunokhod 2 was an improved version of its predecessor and was equipped with a third TV camera, an improved eight-wheel traction system, and additional scientific instrumentation. By the end of its first lunar day, Lunokhod 2 had already traveled further than Lunokhod 1 in its entire operational life. On 9 May, the rover inadvertently rolled into a crater and dust covered its solar panels, disrupting temperatures in the vehicle. Attempts to save the rover failed, and on 3 June, the Soviet news agency announced that its mission was over. Before last contact, the rover took 80,000 TV pictures and 86 panoramic photos and had performed hundreds of mechanical and chemical surveys of the soil. The Soviets later revealed that during a conference on planetary exploration in Moscow, 29 January to 2 February 1973 (that is, after the landing of Luna 21), an American scientist had given photos of the lunar surface around the Luna 21 landing site to a Soviet engineer in charge

of the Lunokhod 2 mission. These photos, taken prior to the Apollo 17 landing, were later used by the "driver team" to navigate the new rover on its mission on the Moon.

138)

**Pioneer 11**

**Nation:** U.S. (53)
**Objective(s):** Jupiter flyby, Saturn flyby
**Spacecraft:** Pioneer-G
**Spacecraft Mass:** 258.5 kg
**Mission Design and Management:** NASA ARC
**Launch Vehicle:** Atlas-Centaur (AC-30 / Atlas 3D no. 5011D / Centaur D-1A)
**Launch Date and Time:** 6 April 1973 / 02:11 UT
**Launch Site:** ETR / launch complex 36B
**Scientific Instruments:**

1) imaging photopolarimeter
2) magnetometer
3) infrared radiometer
4) plasma analyzer
5) ultraviolet photometer
6) charged-particle composition instrument
7) cosmic-ray telescope
8) Geiger tube telescopes
9) asteroid/meteoroid detector
10) Jovian trapped radiation detector
11) meteoroid detector
12) fluxgate magnetometer

**Results:** Pioneer 11, the sister spacecraft to Pioneer 10, was the first humanmade object to fly past Saturn and also returned the first pictures of the polar regions of Jupiter. After two midcourse corrections (on 11 April 1973 and 7 November 1974), Pioneer 11 penetrated the Jovian bow shock on 25 November 1974. The spacecraft's closest approach to Jupiter occurred at 05:22 UT on 3 December 1974 at a range of 42,760 kilometers from the planet's cloud tops, three times closer than Pioneer 10. It was traveling faster than any humanmade object at the time—171,000 kilometers per hour. Because of its high speed during the encounter, the spacecraft's exposure to radiation was much less than that of its predecessor. Pioneer 11 repeatedly crossed Jupiter's bow shock, indicating that the Jovian magnetosphere changes its boundaries as it is buffeted by the solar wind. Pioneer 11 used Jupiter's massive gravitational field to swing back across the solar system to set itself on a flyby course with Saturn. After its Jupiter encounter, on 16 April 1975, the micrometeoroid detector was turned off because it was issuing spurious commands that were interfering with other instruments. Pioneer 11 detected Saturn's bow shock on 31 August 1979, about 1.5 million kilometers out from the planet, thus providing the first conclusive evidence of the existence of Saturn's magnetic field. The spacecraft crossed the planet's ring plane beyond the outer ring at 14:36 UT on 1 September 1979 and then passed by the planet at 16:31 UT for a close encounter at a range of 20,900 kilometers. It was moving at a relative speed of 114,100 kilometers per hour at the point of closest approach. Among Pioneer 11's many discoveries was a narrow ring outside the A ring named the "F" ring and a new satellite 200 kilometers in diameter. The spacecraft recorded the planet's overall temperature at –180°C and photographs indicated a more featureless atmosphere than that of Jupiter. Analysis of data suggested that the planet was primarily made of liquid hydrogen. After leaving Saturn, Pioneer 11 headed out of the solar system in a direction opposite to that of Pioneer 10—that is, to the center of galaxy in the general direction of Sagittarius. Pioneer 11 crossed the orbit of Neptune on 23 February 1990, thus becoming the fourth spacecraft (after Pioneer 10 and Voyagers 1 and 2) to do so. By 1995, twenty-two years after launch, two instruments were still operational on the vehicle. NASA Ames Research Center finally terminated routine contact with the spacecraft on 30 September 1995. Scientists received a few minutes of good engineering data on 24 November 1995 but lost final contact once Earth permanently moved out of view of the spacecraft's antenna. Like Pioneer 10, Pioneer 11 also carries a plaque with a message for any intelligent beings.

139)

**Explorer 49**

**Nation:** U.S. (54)
**Objective(s):** lunar orbit
**Spacecraft:** RAE-B
**Spacecraft Mass:** 330.2 kg
**Mission Design and Management:** NASA GSFC
**Launch Vehicle:** Delta 1913 (no. 95 / Thor no. 581)
**Launch Date and Time:** 10 June 1973 / 14:13:00 UT

**Launch Site:** ETR / launch complex 17B
**Scientific Instruments:**

1) galactic studies experiment
2) sporadic low-frequency solar radio bursts experiment
3) sporadic Jovian bursts experiment
4) radio emission from terrestrial magnetosphere experiment
5) cosmic source observation experiment

**Results:** This was the final U.S. lunar mission for twenty-one years (until Clementine in 1994). After launch on a direct ascent trajectory to the Moon and one midcourse correction on 11 June, Explorer 49 fired its insertion motor at 07:21 UT on 15 June to enter orbit around the Moon. Initial orbital parameters were 1,334 x 1,123 kilometers at 61.3° inclination. On 18 June, the spacecraft jettisoned its main engine and, using its Velocity Control Propulsion System, circularized its orbit. The spacecraft, with a partially deployed radio-antenna array measuring 183 meters from tip to tip, remains the largest spacecraft in physical dimensions to ever enter lunar orbit. Although the antennas did not deploy to full length, the mission goals were not affected. During its mission, Explorer 49 studied low-frequency radio emissions from the solar system (including the Sun and Jupiter) and other galactic and extra-galactic sources. It was placed in lunar orbit to avoid terrestrial radio interference. NASA announced completion of the mission in June 1975. Last contact was in August 1977.

140)
**Mars 4**
**Nation:** USSR (86)
**Objective(s):** Mars orbit
**Spacecraft:** M-73 (no. 52S)
**Spacecraft Mass:** 3,440 kg
**Mission Design and Management:** GSMZ Lavochkin
**Launch Vehicle:** 8K82K + Blok D (Proton-K no. 261-01)
**Launch Date and Time:** 21 July 1973 / 19:30:59 UT
**Launch Site:** NIIP-5 / launch site 81L
**Scientific Instruments:**

1) atmospheric radio-probing instrument
2) radiotelescope
3) infrared radiometer
4) spectrophotometer
5) narrow-band photometer
6) narrow-band interference-polarization photometer
7) imaging system
8) photometers
9) two polarimeters
10) ultraviolet photometer
11) scattered solar radiation photometer
12) gamma spectrometer
13) magnetometer
14) plasma traps
15) multichannel electrostatic analyzer

**Results:** Mars 4 was one of four Soviet spacecraft of the 3M (or M-73) series launched in 1973. Soviet planners were eager to preempt the American Viking missions planned for 1976 but were limited by the less advantageous positions of the planets that allowed the Proton boosters to launch limited payloads toward Mars. The Soviets thus separated the standard pair of orbiter-lander payload combinations into two orbiters and two landers. Less than four months prior to launch, ground testing detected a major problem with the 2T312 transistors used on all four vehicles. An analysis showed that the transistors' failure rate began to increase after 1.5 to 2 years of operation—that is, just about when the spacecraft would reach Mars. Despite the roughly 50-percent odds of success, the government decided to proceed with the missions. The first spacecraft, Mars 4, successfully left Earth orbit and headed toward Mars and accomplished a single midcourse correction on 30 July 1973, but soon two of three channels of the onboard computer failed due to the faulty transistors. As a result, the second midcourse correction could not be implemented. With no possibility for Mars orbit insertion, Mars 4 flew by the Red Planet at 15:34 UT on 10 February 1974 at a range of 1,844 kilometers. Ground control was able to command the vehicle to turn on its imaging system at 15:32:41 UT to begin a short photography session of the Martian surface during the flyby. During 6 minutes, cameras performed one regular cycle of imaging that included two panoramas of the surface. The spacecraft eventually entered heliocentric orbit.

141)

**Mars 5**

**Nation:** USSR (87)
**Objective(s):** Mars orbit
**Spacecraft:** M-73 (no. 53S)
**Spacecraft Mass:** 3,440 kg
**Mission Design and Management:** GSMZ Lavochkin
**Launch Vehicle:** 8K82K + Blok D (Proton-K no. 262-01)
**Launch Date and Time:** 25 July 1973 / 18:55:48 UT
**Launch Site:** NIIP-5 / launch site 81P
**Scientific Instruments:**

1) atmospheric radio-probing instrument
2) radiotelescope
3) infrared radiometer
4) spectrophotometer
5) narrow-band photometer
6) narrow-band interference-polarization photometer
7) imaging system
8) photometers
9) two polarimeters
10) ultraviolet photometer
11) scattered solar radiation photometer
12) gamma spectrometer
13) magnetometer
14) plasma traps
15) multichannel electrostatic analyzer

**Results:** Mars 5 was the sister Mars orbiter to Mars 4. After two midcourse corrections on 3 August 1973 and 2 February 1974, Mars 5 successfully fired its main engine at 15:44:25 UT to enter orbit around the planet. Initial orbital parameters were 1,760 x 32,586 kilometers at 35°19'17" inclination. Soon after orbital insertion, ground controllers detected the slow depressurization of the main instrument compartment on the orbiter—probably as a result of an impact with a particle during or after orbital insertion. Calculations showed that at the current rate of loss of air, the spacecraft would be operational for approximately three weeks. Scientists drew up a special accelerated science program that included imaging of the surface at 100 meters resolution. Five imaging sessions between 17 and 26 February 1974 produced a total of 180 frames of 43 usable photographs. Additionally, Mars 5 took five panoramas of the surface. The last communication with Mars 5, when the final panorama was transmitted back to Earth, took place on 28 February 1974, after which pressure in the spacecraft decreased to below working levels. Mars 5 photos, some of which were of comparable quality to those of Mariner 9, clearly showed surface features that indicated erosion caused by free-flowing water. Mars 5 was supposed to act as a data relay for the Mars 6 and Mars 7 landers but was obviously unable to do so.

142)

**Mars 6**

**Nation:** USSR (88)
**Objective(s):** Mars flyby and Mars landing
**Spacecraft:** M-73 (no. 50P)
**Spacecraft Mass:** 3,260 kg
**Mission Design and Management:** GSMZ Lavochkin
**Launch Vehicle:** 8K82K + Blok D (Proton-K no. 281-01)
**Launch Date and Time:** 5 August 1973 / 17:45:48 UT
**Launch Site:** NIIP-5 / launch site 81L
**Scientific Instruments:**

Bus:

1) magnetometer
2) plasma traps
3) cosmic-ray sensors
4) micrometeoroid detectors
5) Zhemo instrument for study of solar proton and electron fluxes

Lander:

1) thermometer
2) barometer
3) accelerometer
4) radio-altimeter
5) mass spectrometer
6) soil analyzer

**Results:** Mars 6 was one of two landers launched by the Soviet Union during the 1973 launch window. The landers were very similar in design to the Mars 2 and Mars 3 landers dispatched by the Soviets in 1971, except that the spacecraft was now composed of a flyby vehicle (instead of an orbiter) and a lander. Mars 6 completed its first midcourse correction en route to Mars on 13 August 1973. A few days later, there was a major failure in the telemetry system that transmitted scientific and operations data from the spacecraft. Only two channels remained operational, neither of which pro-

vided the ground with any data on the status of the flyby vehicle's systems. Amazingly, the flyby spacecraft automatically performed all its functions, and on 12 March 1974, the lander successfully separated from its mother ship at a distance of 48,000 kilometers from Mars. Three hours later, it entered the Martian atmosphere. The parachute system deployed correctly at an altitude of 20 kilometers, and scientific instruments began to record data as the probe descended. Data seemed to indicate that the lander was rocking back and forth under its parachute far more vigorously than expected. Moments before expected landing, the ground lost contact with the probe. The last confirmed data was information on ignition of the soft-landing engines at 08:58:20 UT. The probe landed at 09:11 UT at 23°54' south latitude and 19°25' west longitude. Later investigation never conclusively identified a single cause of loss of contact. Probable reasons included failure of the radio system or landing in a geographically rough area. All data from the Mars 6 lander was transmitted via the Mars 6 flyby bus, which also collected scientific information during its short flyby.

143)
**Mars 7**
**Nation:** USSR (89)
**Objective(s):** Mars flyby and Mars landing
**Spacecraft:** M-73 (no. 51P)
**Spacecraft Mass:** 3,260 kg
**Mission Design and Management:** GSMZ Lavochkin
**Launch Vehicle:** 8K82K + Blok D (Proton-K no. 281-02)
**Launch Date and Time:** 9 August 1973 / 17:00:17 UT
**Launch Site:** NIIP-5 / launch site 81P
**Scientific Instruments:**

Bus:
1) magnetometer
2) plasma traps
3) cosmic-ray sensors
4) micrometeoroid detectors
5) Zhemo instrument for study of solar proton and electron fluxes
6) Stereo antenna

Lander:
1) thermometer
2) barometer
3) accelerometer
4) radio-altimeter
5) mass spectrometer
6) soil analyzer

**Results:** Mars 7 was the last of the four Soviet spacecraft sent to Mars in the 1973 launch window (although it arrived at Mars prior to Mars 6). On its way to Mars, the spacecraft performed a single midcourse correction on 16 August 1973. En route to Mars, there were failures in the communications systems, and controllers were forced to maintain contact via the only remaining radio communications complex. On 9 March 1974, the flyby spacecraft ordered the lander capsule to separate for its entry into the Martian atmosphere. Although the lander initially refused to "accept" the command to separate, it eventually did accept it. Ultimately, the lander's main retro-rocket engine failed to fire to initiate entry into the Martian atmosphere. As a result, the lander flew by the planet at a range of 1,300 kilometers and eventually entered heliocentric orbit. The flyby probe did, however, manage to collect data during its short encounter with the Red Planet. The failures on both Mars 4 (computer failure) and Mars 7 (retro-rocket ignition failure) were probably due to the faulty transistors, installed in the circuits of the onboard computer, which were detected prior to launch.

144)
**Mariner 10**
**Nation:** U.S. (55)
**Objective(s):** Mercury flyby, Venus flyby
**Spacecraft:** Mariner-73J / Mariner-J
**Spacecraft Mass:** 502.9 kg
**Mission Design and Management:** NASA JPL
**Launch Vehicle:** Atlas-Centaur (AC-34 / Atlas 3D no. 5014D / Centaur D-1A)
**Launch Date and Time:** 3 November 1973 / 05:45:00 UT
**Launch Site:** ETR / launch complex 36B
**Scientific Instruments:**

1) imaging system
2) infrared radiometer
3) ultraviolet airglow spectrometer
4) ultraviolet occultation spectrometer
5) two magnetometers
6) charged-particle telescope
7) plasma analyzer

**Results:** Mariner 10 was the first (and only) spacecraft sent to the planet Mercury, the first mission to explore two planets (Mercury and Venus) during a single mission, the first to use gravity-assist to change its flight path, the first to return to its target after an initial encounter, and the first to use the solar wind as a major means of spacecraft orientation during flight. The primary goal of Mariner 10 was to study the atmosphere (if any), surface, and physical characteristics of Mercury. Soon after leaving Earth orbit, the spacecraft returned photos of both Earth and the Moon as it sped to its first destination, Venus. During the coast, there were numerous technical problems, including malfunctions in the high-gain antenna and the attitude-control system. After midcourse corrections on 13 November 1973 and 21 January 1974, Mariner 10 approached Venus on 5 February 1974 and returned a total of 4,165 photos of the planet and collected important scientific data during its encounter. The closest flyby range was 5,768 kilometers at 17:01 UT. Assisted by Venusian gravity, the spacecraft now headed to the innermost planet, which it reached after another midcourse correction on 16 March 1974. As Mariner 10 approached Mercury, its photos began to show a very Moon-like surface with craters, ridges, and chaotic terrain. The spacecraft's magnetometers revealed a weak magnetic field. Radiometer readings suggested nighttime temperatures of –183°C and maximum daytime temperatures of 187°C. The closest encounter was at 20:47 UT on 29 March 1974 at a range of 703 kilometers. Having looped around the Sun, Mariner 10 flew by Mercury once more on 21 September 1974 at a more distant range of 48,069 kilometers. The spacecraft used solar pressure on its solar panels and high-gain antenna for attitude control. A third and final encounter, the closest to Mercury, took place on 16 March 1975 at a range of 327 kilometers. Contact with the spacecraft was terminated on 24 March 1975.



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