4.2.6 Missions

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The following tables summarize the successful and partly successful planetary missions from the past up until the present (status October 2008). Table 1 lists the numbers of missions to specific targets. Tables 2 - 4 list missions to terrestrial planets, tables 5 - 8 missions to the gas giants, and tables 9 - 13 missions to the Moon, comets, asteroids, dwarf planets, and satellites. Landing site coordinates are given in the respective entry. Please note that coordinates for some missions to Mars, Venus, and the Moon are based on obsolete coordinate systems and do not correspond to current systems defined in the IAU 2006 report (see Section 4.2.3.1). The tables do not list instrumentations. The interested reader is referred to [07Fal].

The column "type" contains categories with the following meanings: "Fly by" are missions, which pass the target body and continue in an orbit around the Sun or on a course leaving the Solar System. Circumlunar flights like Luna 3 are also included. "Orbiter" are missions to orbit the target body. "Hard landing" are spacecraft which crash on the body, and are considered non functional after contact with the surface.[1] "Soft landing" are missions designed to survive and operate after landing. "Atmosphere probe" are missions to descent/drift through an atmosphere; they need not survive the landing on the surface (typical early Venus spacecraft) – the same applies to atmosphere balloons.[2] "Rover" are soft-landing missions that have a rover on board. "Return to Earth" are missions that return samples or astronauts. "Landing Module" is only used for manned lunar missions. "Sample Return" are missions that collect samples for return to Earth. All tables listing missions are ordered by launch date from oldest to youngest.

Abbreviations

AP	Atmosphere probe
FB	Fly by
HL	Hard landing
L	Lander
LM	Landing module
LR	Lunar rover
O	Orbiter
R	Rover
RtE	Return to Earth
SL	Soft landing
SR	Sample return

Table 1. Number of missions to individual celestial bodies (several mission were directed to more than one celestial body)

Body	Number of Missions
Mercury	2
Venus	41
Mars	38
Jupiter	8
Saturn	4
Uranus	1
Neptune	1
Moon	105
Dwarf planets	2
Asteroids	9
Comets	11
Phobos	3
Titan	1

[1]) [07Bal].
[2]) [07Bal].

4.2.6.1 The inner Solar System

Table 2. Mercury

Mission	Type	Notes	Launch	Ref.
Mariner 10 (USA)	FB	3 fly bys, first time gravity assist applied in planetary mission, fly by March 1974, September 1974, March 1975, first dual-planet mission	3. Nov. 1973	[3]
Messenger (USA)	O	First fly by January 2008	3. Aug. 2004	[4]

Table 3. Venus

Mission	Type	Notes	Launch	Ref.
Mariner 2 (USA)	FB	Fly by December 1962	27. Aug. 1962	[5]
Venera 3 (USSR)	AP	First space probe to reach surface of another planet, failed to send data	16. Nov. 1965	[6]
Venera 4 (USSR)	AP	Stopped transmitting before reaching surface, transmitted for 94 minutes during entry, crushed by atmosphere pressure; 19°N, 38°E	12. June 1967	[7]
Mariner 5 (USA)	FB	Fly by October 1967	14. June 1967	[8]
Venera 5 (USSR)	AP	Transmitted for 53 minutes during descent, crushed by atmosphere pressure; –3°N, 18°E	5. Jan. 1969	[9]
Venera 6 (USSR)	AP	Transmitted for 51 minutes, crushed by atmosphere pressure; –5°N, 23°E	10. Jan. 1969	See 9
Venera 7 (USSR)	AP	Transmitted 23 minutes from surface; –5°N, 351°E	17. Aug. 1970	See 9
Venera 8 (USSR)	AP	Transmitted roughly for 51 minutes from surface; –10°N, 335°E	27. Mar. 1972	[10]
Mariner 10 (USA)	FB	First time swing by used to reach another planet, fly by February 1973, first dual-planet mission	3. Nov. 1973	[11]
Venera 9 (USSR)	O, SL	First images of surface, transmitted for 53 minutes from surface; 31.7°N, 290.8°E	8. June 1975	[12]
Venera 10 (USSR)	O, SL	Transmitted for 65 minutes after landing; 16°N, 291°E; or 16°N, 290.8°E	14. June 1975	See 12
Pioneer-Venus 1 (USA)	O	Double mission with Pioneer-Venus 2	20. May 1978	[13]
Pioneer-Venus 2 (USA)	AP	4 atmosphere probes, double mission with Pioneer-Venus 1, one atmosphere probe survived impact and transmitted for about 60 minutes; 4.4°N, 304°E; 59.3°N, 4.8°E; –81.7°N (or –31.3°N), 317°E; –28.7°N, 56.7°E	8. Aug. 1978	[14]

[3]) [01Eng], [05Eng], [97Gre], [02Sid], [LPS], [NMLR].
[4]) [05Eng], [LPS].
[5]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE], [NMLR].
[6]) [97Gre], [02Sid], [01Eng], [LPS], [PE], [07Bal].
[7]) [97Gre], [02Sid], [01Eng], [LPS], [PE], [07Bal], [92Bol], [92BAS].
[8]) [97Gre], [02Sid], [01Eng], [05Eng], [NMLR], [LPS].
[9]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [07Bal], [92Bol], [92BAS].
[10]) [97Gre], [02Sid], [01Eng], [LPS], [PE], [07Bal], [92Bol], [92BAS].
[11]) [01Eng], [05Eng], [97Gre], [02Sid], [NMLR], [LPS].
[12]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [07Bal], [92Bol], [92BAS].
[13]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [NMLR].
[14]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [NMLR], [07Bal], [92BAS].

Mission	Type	Notes	Launch	Ref.
Venera 11 (USSR)	FB, SL	Transmitted for about 95 minutes after landing; −14°N, 299°E	9. Sept. 1978	[15]
Venera 12 (USSR)	FB, SL	Transmitted for about 110 minutes after landing; −7°N, 294°E	14. Sept. 1978	See 15
Venera 13 (USSR)	FB, SL	Survived 127 minutes, soil investigation, first colour images of surface; −7.5°N, 303.5°E	30. Oct. 1981	[16]
Venera 14 (USSR)	FB, SL	Survived for 57 minutes; −13°N, 310°E	4. Nov. 1981	See 16
Venera 15 (USSR)	O	Radar mapping of surface	2. June 1983	[17]
Venera 16 (USSR)	O	Radar mapping of surface	7. June 1983	[18]
Vega 1 (USSR)	FB, SL, AP	Main spacecraft continued on to comet Halley for fly by, atmosphere probe was a balloon; 8.1°N, 176.7°E	15. Dec. 1984	[19]
Vega 2 (USSR)	FB, SL, AP	Main spacecraft continued on to comet Halley for fly by, atmosphere probe was a balloon; −7.2°N, 179.4°E	21. Dec. 1984	[20]
Magellan (USA)	O	First global topography using radar mapping techniques	4. May. 1989	[21]
Galileo(USA)	FB	Fly by Venus February 1990	18. Oct. 1989	[22]
Venus Express (ESA)	O	In operation	9. Nov. 2005	[23]

Failed missions: 1961-63 Sputnik 7 (AP), Venera 1 (AP), Mariner 1 (FB), Sputnik 19 (AP), Sputnik 20 (AP), Sputnik 21 (FB), Kosmos 21 (FB); **1964-66** Venera 1964 A (FB), Venera 1964 B (FB), Kosmos 27 (AP), Zond 1 (AP), Venera 2 (FB), Kosmos 96 (FB or L), Venera 1965 A (FB), **1967-72** Kosmos 167 (AP), Kosmos 359 (AP), Kosmos 482 (AP)

Table 4. Mars

Mission	Type	Notes	Launch	Ref.
MARS 1 (USSR)	FB	Communication failed, silent fly by, collected data on interplanetary space	1. Nov. 1962	[24]
Mariner 4 (USA)	FB	First successful fly by, first images	28. Nov. 1964	[25]
Mariner 6 (USA)	FB	Fly by at about 3,500 km	25. Feb. 1969	[26]
Mariner 7 (USA)	FB	Fly by at about 3,500 km	27. Mar. 1969	See 26
MARS 2 (USSR)	O, SL	Lander failed (transmission failed, dust storm or crashed), orbiter transmitted data; 4°N, 313°E	19. May 1971	[27]
MARS 3 (USSR)	O, SL	Lander transmitted 20s (transmission failed, dust	28. May1971	[28]

[15]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [07Bal], [92Bol], [92BAS].
[16]) [97Gre], [02Sid], [01Eng], [LPS], [07Bal], [92Bol], [92BAS].
[17]) [97Gre], [02Sid], [LPS].
[18]) [97Gre], [02Sid], [01Eng], [LPS].
[19]) [97Gre], [02Sid], [LPS], [PE], [07Bal], [92BAS].
[20]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [07Bal], [92BAS].
[21]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [NMLR].
[22]) [01Eng], [05Eng], [02Sid], [LPS], [PE], [NMLR].
[23]) [ESA], [LPS].
[24]) [97Gre], [02Sid], [LPS], [PE].
[25]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [NMLR].
[26]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [NMLR].
[27]) [05Eng], [97Gre], [02Sid], [PE], [LPS], [07Bal].
[28]) [05Eng], [97Gre], [02Sid], [PE], [LPS], [07Bal], [92Bol].

Mission	Type	Notes	Launch	Ref.
		storm), orbiter transmitted data; −45°N, 202°E		
Mariner 9 (USA)	O	First space craft to enter orbit around a planet	30. May 1971	[29]
MARS 4 (USSR)	O	Fly by, was supposed to act as data relay for Mars 6 and 7	21. July 1973	[30]
MARS 5 (USSR)	O	Operated for only short period, was supposed to act as data relay for Mars 6 and 7	25. July 1973	[31]
MARS 6 (USSR)	FB, SL	Lander crashed (but sent data during descent); −24°N, 340°E; or −24°N, 341°E	5. Aug. 1973	[32]
MARS 7 (USSR)	FB, SL	Failed (landing probe did fly by), fly by probe collected data	9. Aug. 1973	[33]
Viking 1 (USA)	O, SL	First analysis of surface material; 22.269628°N, 312.050381°E	20. Aug. 1975	[34]
Viking 2 (USA)	O, SL	Lander transmitted data until 1980; 47.668093°N, 134.282101°E	9. Sept. 1975	See 34
Phobos 2 (USSR)	Mars O, Phobos SL	Failed (contact lost after initial return of data)	12. July 1988	[35]
Mars Global Surveyor (USA)	O	First global digital terrain model	7. Nov. 1996	[36]
Mars Pathfinder (USA)	SL, R	Rover Sojourner; 19.099641°N, 326.747364°E (initial landing site)	4. Dec. 1996	[37]
Nozomi (Planet B) (Japan)	O	Fly by, first Japanese mars space probe	3. July 1998	[38]
Mars Odyssey (USA)	O	Detailed mineralogical analysis	7. Apr. 2001	[39]
Mars Express (ESA)	O, SL	Beagle 2 Lander failed	2. June 2003	[40]
Mars Exploration Rover (USA)	SL, R	Rover Spirit; −14.571892°N, 175.47848°E; or −14.5692°N, 175.4729°E (initial landing site)	10. June 2003	[41]
Mars Exploration Rover (USA)	SL, R	Rover Opportunity; −1.948282°N, 354.47417°E; or −1.9462°N, 354.4734°E (initial landing site)	8. July 2003	See 41
Mars Reconn. Orbiter (USA)	O	In operation	12. Aug. 2005	[42]
Phoenix (USA)	SL	Landed in May 2008; 68.15°N, 234.1°E	4. Aug. 2007	[43]

[29]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE], [NMLR].
[30]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS].
[31]) [02Sid], [05Eng], [01Eng], [LPS].
[32]) [02Sid], [05Eng], [01Eng], [LPS], [07Bal], [92Bol], [92Sny].
[33]) [02Sid], [05Eng], [01Eng], [LPS], [07Bal].
[34]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE], [NMLR], [07Bal], [06Kon].
[35]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE], [07Bal].
[36]) [98ESF], [02Sid], [05Eng], [LPS], [NMLR], [PE].
[37]) [98ESF], [02Sid], [LPS], [PE], [NMLR], [07Bal], [06Kon].
[38]) [02Sid], [05Eng], [01Eng], [LPS].
[39]) [05Eng], [LPS].
[40]) [05Eng], [ESA], [LPS], [07Bal].
[41]) [05Eng], [LPS], [07Bal], [05Li].
[42]) [05Eng], [LPS].
[43]) [05Eng], [LPS], [07Bal].

Failed missions: 1960-64 Mars 1960 A (FB or AP), Mars 1960 B (FB or AP), Sputnik 22 (FB), Sputnik 24 (AP), Mariner 3 (FB), Zond 2 (FB); **1969-71** Mars 1969A (O), Mars 1969B (O), Mariner 8 (O), Kosmos 419 (O or O, L); **1988-99** Phobos 1 (O, L), Mars Observer (O), Mars'96 (O, L), Mars Climate Orbiter (O), Mars Polar Lander (SL)

4.2.6.2 The outer Solar System

Table 5. Jupiter

Mission	Type	Notes	Launch	Ref.
Pioneer 10 (USA)	FB	Fly by December 1973, first vehicle placed on a trajectory to escape Solar System; first human made object to leave Solar System; also returned images of Callisto, Ganymede, and Europa	2. Mar. 1972	[44]
Pioneer 11 (USA)	FB	Fly by December 1974	6. Apr. 1973	See 44
Voyager 2 (USA)	FB	Fly by July 1979, also images of Amalthea, Io, Europa, Ganymede, and Callisto	20. Aug. 1977	See 44
Voyager 1 (USA)	FB	Fly by March 1979, also images of Amalthea, Io, Europa, Ganymede, and Callisto	5. Sept. 1977	See 44
Galileo (USA)	O, AP	Arrival atmosphere probe December 1995, multiple fly by of Ganymede, Europa, Callisto, Io, Amalthea	18. Oct. 1989	[45]
Ulysses (USA/ESA)	FB	Fly by February 1992, Space probe to investigate Sun	6. Oct. 1990	[46]
Cassini/Huygens (USA /ESA)	FB	Destination Saturn (orbiter and soft landing), fly by 2000	15. Oct. 1997	[47]
New Horizons (USA)	FB	Destination is Pluto and its moon Charon, fly by 2007	19. Jan. 2006	[48]

Table 6. Saturn

Mission	Type	Notes	Launch	Ref.
Pioneer 11 (USA)	FB	Fly by September 1979	6. Apr. 1973	[49]
Voyager 2 (USA)	FB	Fly by August 1981, also images of Titan, Enceladus, Tethys, Rhea, Dione, Mimas, and Phoebe	20. Aug. 1977	[50]
Voyager 1 (USA)	FB	Fly by November 1980, also images of Titan, Mimas, Enceladus, Tethys, Dione, Hyperion, and Rhea	5. Sept. 1977	[51]
Cassini-Huygens (USA /ESA)	Saturn O, Titan AP	Atmosphere probe named Huygens, fly by Phoebe, Iapetus, Enceladus, Dione, Rhea, with Tethys, Mimas, and Hyperion, multiple fly by of Titan	15. Oct. 1997	[52]

[44]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE], [NMLR].
[45]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE], [NMLR], [07Bal].
[46]) [02Sid], [LPS].
[47]) [02Sid], [01Eng], [05Eng], [LPS].
[48]) [LPS].
[49]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE].
[50]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [PE], [NMLR].
[51]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE].
[52]) [98ESF], [01Eng], [05Eng], [02Sid], [LPS], [07Bal].

Table 7. Uranus

Mission	Type	Notes	Launch	Ref.
Voyager 2 (USA)	FB	Fly by January 1986, also images of Miranda, Oberon, Ariel, Umbriel, and Titania	20. Aug. 1977	[53]

Table 8. Neptune

Mission	Type	Notes	Launch	Ref.
Voyager 2 (USA)	FB	Fly by August 1989, also images of Triton, Nereid, Proteus, Naiad	20. Aug. 1977	See 53

4.2.6.3 Missions to other celestial bodies

Table 9. Moon

Mission	Type	Notes	Launch	Ref.
Luna 1 (USSR)	HL	Fly by, passed moon at distance of 6000 km	2. Jan. 1959	[54]
Pioneer 4 (USA)	FB	Fly by of Moon at 60,000 km	3. Mar. 1959	[55]
Luna 2 (Ye-1a) (USSR)	HL	Crashed near crater Autolycus, 30°N, 0°E; or 29.1°N, 0°E	12. Sept. 1959	[56]
Luna 3 (Ye-2) (USSR)	FB	Highly elliptical orbit around Earth, first pictures from far side of Moon	4. Oct. 1959	[57]
Ranger 3 (USA)	SL	Missed Moon (malfunction guidance system), measurements of interplanetary Gamma-ray flux	26. Jan. 1962	[58]
Ranger 5 (USA)	SL	Missed Moon, collected Gamma-ray data	18. Oct. 1962	[59]
Ranger 7 (USA)	HL	Crashed in Mare Nubium or Mare Cognitum, transmitted images, −10.70°N, 339.33°E	28. July 1964	[60]
Ranger 8 (USA)	HL	Crashed in Mare Tranquillitatis, transmitted images, 2.71°N, 24.81 °E	17. Feb. 1965	[61]
Ranger 9 (USA)	HL	Crashed in Crater of Alphonsus, transmitted images, −12.91° N, 357.62° E	21. Mar. 1965	[62]
Zond 3 (USSR)	FB	Imaged Moon	18. July 1965	[63]
Luna 9 (Ye-6M) (USSR)	SL	First successful soft landing, landed in Oceanus Procellarum, 7.14°N, 295.62°E; or 7.13°N, 295.63°E	31. Jan. 1966	[64]
Luna 10 (Ye-6S) (USSR)	O	First artificial satellite of the Moon	31. Mar. 1966	[65]

[53]) [97Gre], [02Sid], [01Eng], [05Eng] [LPS], [PE], [NMLR].
[54]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[55]) [LE], [97Gre], [01Eng], [02Sid], [LPS], [NMLR].
[56]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [92 Bol], [LCM].
[57]) Ye-2 designation for farside photography (fly by), [LE], [97Gre] [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[58]) [LE], [97Gre], [01Eng], [02Sid], [LPS], [NMLR], [07Bal].
[59]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR], [07Bal].
[60]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR], [07Bal], [LCM].
[61]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Bal], [LCM].
[62]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Bal], [LCM].
[63]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[64]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM], [92Bol].
[65]) Ye-6S designation for orbiter, [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].

Mission	Type	Notes	Launch	Ref.
Surveyor 1 (USA)	SL	Near crater Flamsteed, Ocean of Storm, –2.44°N, 316.66°E	30. May 1966	[66]
Lunar Orbiter 1 (USA)	O	Purpose: preparation for Apollo landings sites	10. Aug. 1966	[67]
Luna 11 (Ye-6LF) (USSR)	O	Performed 277 orbits	24. Aug. 1966	[68]
Luna 12 (Ye-6LF) (USSR)	O	Transmissions ended in January 1967	22. Oct. 1966	[69]
Lunar Orbiter 2 (USA)	O	Purpose: preparation for Apollo landings sites	6. Nov. 1966	[70]
Luna 13 (Ye-6M) (USSR)	SL	Landed in Oceanus Procellarum, 18.9°N, 298°E; or 18.87°N, 297.95°E	21. Dec. 1966	[71]
Lunar Orbiter 3 (USA)	O	Purpose: preparation for Apollo landings sites	5. Feb. 1967	[72]
Surveyor 3 (USA)	SL	Landed in Oceanus Procellarum, –3.0159°N, 336.5822°E	17. Apr. 1967	[73]
Lunar Orbiter 4 (USA)	O	Imaged Moon until end of May 1967	4. May 1967	[74]
Explorer 35 (USA)	O	Ended operation in 1973	19. July 1967	[75]
Lunar Orbiter 5 (NASA)	O	Imaged Moon until mid-August 1967	1. Aug. 1967	[76]
Surveyor 5 (USA)	SL	Landed in Mare Tranquillitatis, 1.49°N, 23.2°E	8. Sept. 1967	[77]
Surveyor 6 (USA)	SL	Landed in Sinus Medii, 0.42°N, 358.62°E	7. Nov. 1967	[78]
Surveyor 7 (USA)	SL	Landed near crater Tycho, –41.01°N, 348.59°E	7. Jan. 1968	[79]
Luna 14 (Ye-6LS) (USSR)	O	Communication orbiter, Reached lunar orbit, but no publications	7. Apr. 1968	[80]
Zond 5 (USSR)	RtE	Plants and two tortoises were passengers	14. Sept. 1968	[81]
Zond 6 (USSR)	RtE	Minimum distance about 2,400 km	10. Nov. 1968	[82]
Apollo 8 (USA)	O,RtE	Second manned Apollo flight, first manned flight to Moon	21. Dec. 1968	[83]

[66]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR], [07Bal], [LCM].
[67]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR].
[68]) Ye-6LF designation for orbiter, [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[69]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[70]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR].
[71]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM], [92Bol].
[72]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR].
[73]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR], [07Bal], [LCM].
[74]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR].
[75]) [02Sid], [LPS], [NMLR].
[76]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR].
[77]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR], [07Bal], [LCM].
[78]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR], [07Bal], [LCM].
[79]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [NMLR], [07Bal], [LCM].
[80]) Ye-6LS orbiter, [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[81]) [LE], [97Gre], [01Eng], [02Sid], [LPS], [07Har].
[82]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[83]) [97Gre], [05Eng], [LPS].

Mission	Type	Notes	Launch	Ref.
Apollo 10 (USA)	O, LM, RtE	Manned mission, first simulation of landing in lunar orbit	18. May 1969	[84]
Luna 15 (Ye-8-5) (USSR)	SL, SR	Crashed in Mare Crisium after a few orbits, 17°N, 60°E, images, data about gravitational field, chemical composition of lunar rocks	13. July 1969	[85]
Apollo 11 (USA)	O, LM, RtE	First manned landing on Moon, Mare Tranquillitatis, 0.67°N, 23.47°E	16. July 1969	[86]
Zond 7 (USSR)	RtE	Four tortoises on board	7. Aug. 1969	[87]
Apollo 12 (USA)	O, LM, RtE	Second manned landing, Oceanus Procellarum, –3.01°N, 336.58°E	14. Nov. 1969	[88]
Apollo 13 (USA)	O, LM, RtE	Manned mission, no landing after accident occurred	11. Apr. 1970	[89]
Luna 16 (Ye-8-5) (USSR)	SL, SR	Landed in Mare Fecunditatis, returned 100g of soil, –0.65°N, 56.3°E; or –0.68°N, 56.3°E	12. Sept. 1970	[90]
Zond 8 (USSR)	RtE	Minimum distance about 1,110 km	20. Oct. 1970	[91]
Luna 17 (Ye-8) (USSR)	SL, R	Mare Imbrium, rover Lunokhod 1, 38.213°N, 324.803°E	10. Nov. 1970	[92]
Apollo 14 (USA)	O, LM, RtE	Third manned landing, Fra Mauro, –3.65°N, 342.53°E	31. Jan. 1971	[93]
Apollo 15 (USA)	O, LM, LR, RtE	Fourth manned landing, Hadley-Apennines, crew also deployed particle and fields sub satellite, 26.13°N, 3.63°E	26. July. 1971	[94]
Luna 18 (Ye-8-5) (USSR)	SL, SR	Failed (communication ceased), crashed in Mare Fecunditatis after several orbits, 3.57°N, 56.5°E	2. Sept. 1971	[95]
Luna 19 (Ye-8LS) (USSR)	O	Operated for one year	28. Sept. 1971	[96]
Luna 20 (Ye-8-5) (USSR)	SL, SR	Landed in area of Apollonius, returned 50 g of soil, 3.53°N, 56.55°E	14. Feb. 1972	[97]
Apollo 16 (USA)	O, LM, LR, RtE	Fifth manned landing, Descartes Area, crew also deployed particle and fields sub satellite, –8.97°N, 15.5°E	16. Apr. 1972	[98]
Apollo 17 (USA)	O, LM, LR,	Sixth manned landing, Taurus-Littrow, first geologist on Moon, 20.19°N, 30.77°E	7. Dec. 1972	[99]

[84]) [97Gre], [05Eng], [LPS], [NMLR].
[85]) [97Gre], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM].
[86]) [97Gre], [05Eng], [LPS], [NMLR], [LCM].
[87]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[88]) [97Gre], [05Eng], [LPS], [NMLR], [LCM].
[89]) [97Gre], [05Eng], [LPS], [NMLR].
[90]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM], [92Bol].
[91]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[92]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM].
[93]) [97Gre], [05Eng], [LPS], [NMLR], [LCM].
[94]) [97Gre], [05Eng], [02Sid], [LPS], [NMLR], [LCM].
[95]) [LE], [97Gre], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM], [92Bol].
[96]) Ye-8LS designation for orbiter, [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[97]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM], [92Bol].
[98]) [97Gre], [05Eng], [02Sid], [LPS], [NMLR], [LCM].
[99]) [97Gre], [05Eng], [LPS], [NMLR], [LCM].

Mission	Type	Notes	Launch	Ref.
	RtE			
Luna 21 (Ye-8) (USSR)	SL, R	Rover Lunokhod 2, le Monnier crater, 25.85°N, 30.48°E; or 25.85°N, 30.45°E	8. Jan. 1973	[100]
Explorer 49 (USA)	O	Was no lunar mission, but placed in lunar orbit to avoid terrestrial radio interference	10. June 1973	[101]
Luna 22 (Ye-8LS) (USSR)	O	Ended in November 1975	29. May 1974	[102]
Luna 23 (Ye-8-5M) (USSR)	SL, SR	Landing in Mare Crisium, main goal not achieved, 13°N, 62°E	28. Oct. 1974	[103]
Luna 24 (Ye-8-5M) (USSR)	SL, SR	Landed in Mare Crisium, returned 170 g of soil, 12.75°N, 62.2°E	9. Aug. 1976	[104]
Galileo (USA)	FB	2 fly bys in 1990 and 1992	18. Oct. 1989	[105]
Muses-A (Hiten) (Japan)	FB, O	First Japanese moon Orbiter, sub-satellite included	24. Jan. 1990	[106]
Clementine (USA)	O	Was supposed to continue journey to asteroid Geographos, but failed	25. Jan. 1994	[107]
Lunar Prospector (USA)	O	Ended in July 1999	7. Jan. 1998	[108]
SMART-1 (ESA)	O	First European lunar orbiter; tested solar-powered ion drive	27. Sept. 2003	[109]
Selene (Kaguya) (Japan)	O	One main orbiter, two sub satellites	14. Sept. 2007	[110]
CHANG'E 1 (China)	O	Reached planned orbit in November 2007	24. Oct. 2007	[111]
Chandrayaan-1 (India)	O, HL	In orbit, Moon impact probe (MIP) on board	22. Oct. 2008	[112]

Failed missions: 1958-59 Thor-Able 1 (O), Ye-1[113] (HL), Pioneer 1 (O), Ye-1 (HL), Pioneer 2 (O), Ye-1 (HL), Pioneer 3 (FB), Ye-1a (HL), Atlas-Able P-3 (O); **1960-62** Ye-2f (FB), Ye-2f (FB), Atlas-Able P-30 (O), Atlas-Able P-31 (O), Ranger 1 (FB, test flight), Ranger 2 (FB, test flight), Ranger 4 (SL); **1963-65** Ye-6[114] (SL), Ye-6 (SL), Luna 4 (SL), Kosmos 21 (FB), Ranger 6 (HL), Ye-6 (SL), Ye-6 (SL), Kosmos 60 (SL), Luna Ye-6 (SL), Luna 5 (SL), Luna 6 (SL), Luna 7 (SL), Luna 8 (SL); **1966-68** Kosmos 111 (O), Explorer 33 (O), Surveyor 2 (SL), Surveyor 4 (SL), Zond (RtE), Zond (RtE), Zond (RtE); **1969-71** Zond (RtE), Ye-8[115] (SL, R), N-1 L-1S (test flight), Ye-8-5[116] (SL, SR), L-1S, Kosmos 300 (SL, SR),

[100]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM], [92Bol].
[101]) [97Gre], [02Sid], [LPS], [NMLR].
[102]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har].
[103]) [LE], [97Gre], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM].
[104]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS], [07Har], [07Bal], [LCM], [92Bol].
[105]) [97Gre], [02Sid], [LPS].
[106]) [JAXA], [97Gre], [05Eng], [01Eng], [02Sid], [LPS].
[107]) [LE], [97Gre], [05Eng], [01Eng], [02Sid], [LPS].
[108]) [05Eng], [01Eng], [02Sid], [LPS].
[109]) [ESA], [05Eng], [LPS].
[110]) [JAXA], [LPS].
[111]) [LPS].
[112]) [ISRO].
[113]) Ye-1 designation for lunar impact.
[114]) Ye-6 designation for lander.
[115]) Ye-8 designation for rover.

Kosmos 305 (SL, SR), Ye-8-5 (SL, SR), Ye-8-5 (SL, SR); **1972-1975** N1-LOK (O, RtE), Ye-8-5M (SL, SR)

Table 10. Comets

Mission	Type	Notes	Launch	Ref.
Giacobini-Zinner				
ICE (USA)	FB	Former ISEE-3 space probe for sun research, fly by September 1985	12. Aug. 1978	[117]
Comet Halley				
Vega 1 (USSR)	FB	Fly by March 1986; fly by Venus and released Lander and atmosphere balloon	15. Dec. 1984	[118]
Vega 2 (USSR)	FB	Fly by March 1986; fly by Venus and released lander and atmosphere balloon	21. Dec. 1984	See 118
Sakigake (Japan)	FB	Fly by March 1986	7. Jan. 1985	[119]
Giotto (ESA)	FB	Europe's first deep space mission, fly by Halley March 1986; First images of a comet nucleus	2. July 1985	[120]
Suisei (Japan)	FB	Fly by March 1986, planned fly by of Giacobini-Zinner in 1998 cancelled, as well as fly by of comet Tempel-Tuttle	18. Aug. 1985	[121]
Comet Grigg-Skjellerup				
Giotto (ESA)	FB	Fly by July 1992	2. July 1985	[122]
Comet Borrelly				
Deep Space 1 (USA)	FB	Fly by September 2001	24. Oct. 1998	[123]
Comet Wild 2				
Stardust (USA)	FB, SR	Fly by January 2004, extended mission to fly by comet Tempel 1 in 2011, capsule returned to Earth in January 2006, main craft still in orbit around sun	7. Feb. 1999	See 123
Comet 67 P/Churyumov- Gerasimenko				
Rosetta (ESA)	O, SL	Lander Philae, original target was comet 46 P/Wirtanen	2. Mar. 2004	[124]
Comet Tempel 1				
Deep Impact (USA)	FB, HL	Mission extended to fly by comet Hartley 2 in 2010	12. Jan. 2005	[125]

Failed missions: 2002 CONTOUR (FB comets Encke, Schwassmann-Wachmann-3, Comet d'Arrest)

[116]) Ye-8-5 designation for sample return.
[117]) [97Gre], [02Sid], [05Eng], [NMLR], [LPS].
[118]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS].
[119]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [JAXA].
[120]) [97Gre], [02Sid], [01Eng], [05Eng], [ESA], [LPS].
[121]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS], [JAXA].
[122]) [97Gre], [02Sid], [01Eng], [05Eng], [ESA], [LPS].
[123]) [02Sid], [05Eng] [01Eng], [LPS].
[124]) [05Eng], [ESA], [LPS], [07Bal].
[125]) [05Eng], [LPS], [07Bal].

Table 11. Asteroids

Mission	Type	Notes	Launch	Ref.
Ida Galileo (USA)	FB	Very first close-up views of asteroids, fly by August 1993	18. Oct. 1989	[126]
Gaspra Galileo (USA)	FB	Very first close-up views of asteroids, fly by October 1991	18. Oct. 1989	See 126
Mathilde NEAR-Shoemaker (USA)	FB	Fly by June 1997	17. Feb. 1996	[127]
433 Eros NEAR-Shoemaker (USA)	O, HL	landed softly on asteroid, arrival February 2000, first artificial satellite of an asteroid,	17. Feb. 1996	[128]
Masursky Cassini-Huygens (USA /ESA)	FB	Fly by in 2000	15. Oct. 1997	[129]
9969 Braille (1992 KD) Deep Space 1 (USA)	FB	Fly by July 1999	24. Oct. 1998	[130]
Annefrank Stardust (USA)	FB	Fly by November 2002	7. Feb. 1999	[131]
Itokawa Hayabusa (Japan)	SL, SR	First named Muses-C, mission in progress, reached asteroid in September 2005	9. May 2003	[132]
132524 APL New Horizons (USA)	FB	Fly by June 2006	19. Jan 2006	[133]
Vesta DAWN (USA)	O	Supposed to arrive in August 2011	27. Sept. 2007	See 133

Failed missions: 1994 Clementine (FB asteroid Geographos)

Table 12. Dwarf planets

Mission	Type	Notes	Launch	Ref.
Pluto New Horizons (USA)	FB	Supposed to arrive in July 2015	19. Jan. 2006	See 133
Ceres DAWN (USA)	O	Supposed to arrive in February 2015	27. Sept. 2007	See 133

[126]) [97Gre], [02Sid], [01Eng], [05Eng], [LPS].
[127]) [02Sid], [01Eng], [05Eng], [NMLR], [LPS].
[128]) [02Sid], [01Eng], [05Eng], [NMLR], [LPS], [07Bal].
[129]) [02Sid].
[130]) [02Sid], [01Eng], [05Eng], [LPS].
[131]) [05Eng], [LPS].
[132]) [05Eng], [LPS], [JAXA], [07Bal].
[133]) [LPS].

Table 13. Other Moons

Mission	Type	Notes	Launch	Ref.
Phobos				
Phobos 2 (USSR)	Mars O, Phobos SL	Contact lost after initial return of data	12. July 1988	[134]
Mars Express (ESA)	FB	Fly by July and August 2008	2. June 2003	[135]
Titan				
Cassini-Huygens (USA /ESA)	Saturn O, Titan AP	Atmosphere probe named Huygens; −10.33°N, 167.68°E	15. Oct. 1997	[136]

Failed missions: 1988 Phobos 1 (O, SL)

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4.2.6.4 References for 4.2.6

92Bas Basilevsky, A., et al.: In: Barsukov, V.L., et al., editors, Venus, Geology, Geochemistry, and Geophysics, University of Arizona Press, Tucson, London, 1992.
92Bol Bolschakow, Wd., et al.: Atlas of the Terrestrial Planets and Their Moons. Moscow State University Institute for Geodesy and Cartography MIIGAIK, Moscow 1992.
92Sny Snyder, C.W., Moroz, V.I.: In: Kieffer, H.H. et al., editors, Mars, University of Arizona Press, Tucson and London, 1992.
97Gre Greeley, R., Batson, R.: The NASA Atlas of the Solar System, Cambridge University Press, Cambridge, UK 1997.
98Esf Report by European Science Foundation and National Research Council: U.S.-European Collaboration in Space Science, Washington D.C., 1998.
01Eng Engelhardt, W.: Enzyklopädie Raumfahrt, Verlag Harri Deutsch, Frankfurt am Main, 2001.
02Sid Siddiqi, A.A.: Deep Space Chronicle, A Chronology of Deep Space and Planetary Probes 1958-2000, Monographs in Aerospace History, Nr. 24. NASA SP-2002-4524, 2002.
05Eng Engelhardt, W.: Galileo, Cassini, Giotto: Raumsonden erforschen unser Planetensystem, Verlag Harri Deutsch, Frankfurt am Main, 2005.
05Leb Lebreton, J.-P., et al.: Nature **438** (2005) 758.
05Li Li, Rongxing et al.: Photogrammetric Engineering & Remote Sensing **71** (10) (2005) 1129.
06Fol Folkner, W. M., et al.: J. Geophys. Res. **111** (2006).
06Kon Konopliv, A.S., et al.: Icarus **182** (2006) 23.
07Bal Ball, A.J., et al.: Planetary Landers and Entry Probes, Cambridge University Press, Cambridge, UK, 2007.
07Har Harvey, B.: Soviet and Russian Lunar Exploration, Springer (Praxis), Chichester, 2007.
07Fal Falkner, P., et al.: In: G. Schubert and T. Spohn, editors, Treatise on Geophysics - Planets and Moons, Vol. 10, pages 595-641. Elsevier, Amsterdam, 2007.

Internet resources

ESA "ESA Missions" www.sci.esa.int
NMLR "NASA Major Launch Record" http://history.nasa.gov/pocketstats/index.html
PE "Planetary Exploration" http://history.nasa.gov/pocketstats/index.html
LE "Lunar Exploration" http://history.nasa.gov/pocketstats/index.html

[134]) [97Gre], [02Sid], [05Eng], [01Eng], [LPS], [PE], [07Bal].
[135]) [ESA].
[136]) [98ESF], [01Eng], [05Eng], [02Sid], [LPS], [07Bal], [06Fol], [05Leb].

LPS "Lunar and Planetary Science" http://nssdc.gsfc.nasa.gov/planetary/
JAXA "JAXA" http://www.isas.ac.jp/e/enterp/missions/index.shtml
LPI "LPI" http://www.lpi.usra.edu/publications/slidesets/apollolanding/
LCM "Lunar Constants and models" http://ssd.jpl.nasa.gov/?lunar_doc
ISRO "Indian Space Research Organization" www.isro.org