**Designing Robotic Missions to Explore the Solar System: May 2019**

Our goal is to have students become engaged in science investigations and potentially leading to formal science fair projects. To practice a way of guiding your students toward science fair participation, take the perspective of adults and follow these steps with your group to design and build a model of a robotic spacecraft or instrument:

You've participated in several activities and seen slide presentations on how we classify things and on the solar system and its exploration.

- Look over the "Selected Solar System Robotic Missions" on the next page.
- What information about the solar system would be very valuable to know at this point in the history of space exploration?
- What kind of robotic mission could help gather the information we want to have?
- Discuss what type of spacecraft or instrument would be used in this mission.
- Design and build a model of that spacecraft or instrument to share with the entire group.

# Selected Solar System Robotic Missions

| Mission | Year | Planet | Other | Type | Country | Comment |
|---|---|---|---|---|---|---|
| Mariner 2 | 1962 | Venus | | flyby | US | |
| Luna 3 | 1963 | | Moon | flyby | USSR | Imaged far side of the Moon |
| Ranger 7 | 1964 | | Moon | impactor | US | First close up images of surface |
| Mariner 4 | 1964 | Mars | | flyby | US | Southern hemisphere |
| Luna 9 | 1966 | | Moon | lander | USSR | |
| Luna 10 | 1966 | | Moon | orbiter | USSR | 3 pictures of surface |
| Surveyor 1 | | | Moon | lander | US | First US lander |
| Lunar Orbiter 1 | 1966 | | Moon | orbiter | US | First US orbiter |
| Venera 4,5,6 | 1967-69 | Venus | | probe atmos. | USSR | Crushed by atmosphere |
| Mariner 5 | 1967 | Venus | | flyby | US | Duplicate of Mariner 4 w/o camera |
| Apollo 8 | 1968 | | Moon | orbiter | US | First humans to orbit Moon |
| Mariner 6,7 | 1969 | Mars | | flyby | US | Southern hemisphere |
| Apollo 11 | 1969 | | Moon | lander | US | First lunar landing and sample return |
| Venera 7 | 1970 | Venus | | lander | USSR | No camera? Landed on side, weak signal. |
| Luna 17 | 1970 | | Moon | lander | USSR | Lunar rover Lunokhod 1 |
| Mariner 9 | 1971 | Mars | | orbiter | US | Arrived in dust storm |
| Pioneer 10 | 1972 | Jupiter | | flyby | US | |
| Pioneer 11 | 1973 | Saturn | | flyby | US | |
| Mariner 10 | 1973 | Mercury | | flyby | US | 1 Venus and then 3 Mercury flybys , first images |
| Hellos 1 | 1974 | | Sun | orbiter | US, Germany | Orbiting within 0.3 AU of Sun |
| Venera 9 | 1975 | Venus | | lander | USSR | First TV images of surface |
| Viking 1,2 | 1975 | Mars | | lander | US | 2 orbiters and landers |
| Luna 24 | 1976 | | Moon | sample return | USSR | Robotic sample return |
| Voyager 1,2 | 1977 | 4 planets | | flyby | US | Voyager 1: Jupiter, Saturn, and moons<br>Voyager 2: Jup., Sat., Uranus, Neptune, and moons |
| Pioneer 12 | 1978 | Venus | | orbiter | US | Radar mapping of the surface |
| Pioneer 13 | 1978 | Venus | | probe atmos. | US | Multiple atmospheric probes |
| ICE | 1978 | | comet | flyby | US | First comet flyby, Comet Giacobini-Zinner |
| Vega 1,2 | 1984 | Venus | | lander, atm. balloon probe | USSR, France | Both flew by Comet Halley after flying by Venus |
| Giotto | | | comet | flyby | ESA | Comet Halley |
| Galileo | 1989 | Jupiter | asteroid | flyby, orbiter | US | Asteroid Gaspra flyby on way to Jupiter, atmos. probe |
| NEAR | 1996 | | asteroid | orbiter | US | Asteroid Mathilde flyby, asteroid Eros orbiter/lander |
| Mars Pathfinder | 1996 | Mars | | lander/rover | US | Lander with the first Mars rover |
| Cassini-Huygens | 1997 | Saturn | moon | orbiter, atm. probe | US, ESA, Italy | Saturn orbiter with probe of Titan's atmosphere, landing on surface |
| Stardust | 1999 | | comet | flyby, sample return | US | Encountered Comet Wild 2, coma material sample return |
| Hayabusa | 2003 | | asteroid | orb., samp. ret. | Japan | Orbited asteroid Itokawa, landed, returned surface sample |
| Rosetta | 2004 | | comet | orbiter, lander | ESA | |
| MESSENGER | 2004 | Mercury | | orbiter | US | First Mercury orbiter, after three flybys |
| Deep Impact | 2005 | | comet | flyby, impact | US | Impactor observed by flyby spacecraft |
| New Horizons | 2006 | Pluto | | flyby | US | First flyby of Pluto and its satellites and TNO |
| Dawn | 2007 | | asteroids | orbiter | US | Orbited two asteroids: Vesta and Ceres |
| Chandrayaan-1 | 2008 | | Moon | orbiter | India | First Indian lunar mission |
| Chang'e 2 | 2010 | | Moon | orbiter | PR China | First Chinese orbiter, left orbit and flew by ast. Toutatis |
| Juno | 2011 | Jupiter | | orbiter | US | First polar orbit of Jupiter |
| Chang'e 3 | 2013 | | Moon | rover | PR China | First Chinese rover |
| Hayabusa 2 | 2014 | | comet | orb., samp. ret. | Japan | Exploring asteroid 162173 Ryugu |
| OSIRIS REx | 2016 | | asteroid | orb., samp. ret. | US | Orbiting 101955 Bennu |
| InSight | 2018 | | Mars | lander | US | Study Mars Interior |
| Chang'e 4 | 2018 | | Moon | lander & rover | PR China | First landing on far side of Moon |

Mercury: 2 missions (1 multiple flyby, 1 orbiter)
Venus: 24 successful/partially successful missions (16 failures)
Mars: 23 successful missions, 4 partially successful missions, and two flybys (gravity assist) on way to other destinations (27 failures)
Jupiter: 4 missions (2 flybys, 2 orbiters) and 3 flybys (gravity assist) on way to other destinations
Saturn: 4 missions (3 flybys, 1 orbiter)
Uranus, Neptune: 1 mission (flyby)
Pluto: 1 mission (flyby) plus TNO flyby
Moon: 69 successful missions, 54 failures
Asteroids: 12 missions, 8 of which were secondary missions before or after primary mission
Comets: 13 missions, 8 comets (1 orbiter)