

Reconnaissance of life on Moon

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Abstract

Moon landings have been very important stepping-stones in the exploration of the universe, gaining immense amounts of knowledge and technical advancements. This review paper provides compiled data of the successes and milestones achieved by various nations in their respective lunar missions and an overview of the information and knowledge gained by them. The method used is data collection and analysis of various web archives and web sites. The discussion is about the iterations and novelty techniques developed based on the information gained from previous missions and it is the main outcome of this review paper.

Keywords: Moon Landing, Flyby, Launch, Rover, orbiter.

Introduction

Since the birth of humanity, humans have been looking at the night sky and admiring the beauty of the immaculate heavenly bodies, which gave birth to the journey of exploration of this universe. Moon exploration has been one of the most remarkable milestones in this journey.

Starting from 1958, humans have accomplished various types of missions to the Moon, which include impactors, flybys, orbiters, soft landers, rovers, sample returners and crew landers. These were sent by various space agencies such as Soviet Space Agency (USSR), National Aeronautics & Space Administration (USA), China National Space Agency (China), Japan Aerospace Exploration Agency (Japan), European Space Agency (EU), Indian Space Research Organisation (India).

The Soviet Space Agency's LUNA program achieved various milestones. The prominent are: LUNA-1 (1959) which was the first human satellite to perform a flyby over Moon, LUNA-2 (1959) was the first human satellite to impact the Moon, LUNA-3 (1959) captured the images of the far side of the Moon, LUNA-9 (1966) was the first to perform soft landing and provide pictures from the surface of the Moon, LUNA-16 (1970) was the first robotic sample return and LUNA-17 (1970) was the first rover on the Moon.

The LUNAR ORBITER¹ missions (4 & 5) (1967) performed by NASA (USA) enabled us to entirely map the lunar surface. Their APOLLO-8 (1968) mission was the first mission in which humans orbited the Moon. APOLLO-11 (1969) enabled humans to step on Moon whereas APOLLO-17 (1972) was the first mission to enable a scientist to stand on the Moon. Later, JAXA's (Japan) HITEN (1990) was the first satellite to use aerobraking and ISRO's (India) CHANDRAYAAN-1 (2008) was the first satellite to detect water locked in minerals at Moon.

Various Space Programs

A brief overview of lunar missions of various countries/agencies is as follow:

Table 1: Lunar missions launched by Soviet Space Agency (USSR) from 1959 to 1976

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	LUNA-1 [FLYBY]	07-01-1959	Studied interplanetary space, provided data about radiation belt, showed absence of magnetic field around Moon, FLYBY.
2	LUNA-2 [IMPACT]	12-09-1959	Confirmed the findings of LUNA-1, IMPACTED.
3	LUNA-3 [FLYBY]	04-10-1959	Pictures of the far side of the Moon, FLYBY.
4	LUNA-4 [FLYBY]	02-04-1963	MISSED Moons by 8,336 km, unknown objective.
5	LUNA-5 [IMPACT]	09-05-1965	Originally a soft lander, retrorocket system failed, CRASHED.
6	LUNA-6 [FLYBY]	08-06-1965	Mid-course correction failed, MISSED Moon by 1,59,612 km.
7	LUNA-7 [IMPACT]	04-10-1965	Originally a soft lander, CRASHED due to premature firing of retrorocket.
8	LUNA-8 [IMPACT]	03-12-1965	Originally a soft lander, CRASHED due to late firing of retrorocket.
9	LUNA-9 [SOFT LANDER]	31-01-1966	First to achieve soft landing, provided lunar surface images.
10	LUNA-10 [ORBITER]	31-03-1966	Studied IR emissions of the Moon, performed gravitational studies.
11	LUNA-11 [ORBITER]	24-08-1966	Used X-ray & gamma-ray spectroscopy to study composition of lunar soil, studied corpuscular radiations.
12	LUNA-12 [ORBITER]	22-10-1966	Transmitted various photographs (confidential).
13	LUNA-13 [SOFT LANDER]	21-12-1966	Provided panoramic surface pictures, studied lunar surface.
14	LUNA-14 [ORBITER]	07-04-1968	Studied gravitational fields, cosmic rays, solar charged particles.
15	LUNA-15 [ORBITER]	13-07-1969	Studied circumlunar space and gravitational fields.
16	LUNA-16 [SAMPLE RETURN]	12-09-1970	First sample from far side, brought back 101 g of lunar soil.
17	LUNA-17 [ROVER]	10-11-1970	First rover 'LUNOKHOD-1' on Moon, sent 20,000 pictures, 200 panoramas, performed more than 500 soil tests.
18	LUNA-18 [ROVER]	02-09-1971	Originally a rover, CRASHED.

19	LUNA-19 [ORBITER]	28-09-1971	Studied mass concentrations, solar winds.
20	LUNA-20 [SAMPLE RETURN]	14-02-1972	Sent back 30 g of lunar soil.
21	LUNA-21 [ROVER]	08-01-1973	Second rover 'LUNOKHOD-2' on Moon, sent 80,000 pictures, 86 panoramas, planted retroreflectors for laser ranging.
22	LUNA-22 [ORBITER]	29-05-1974	Studied gravitational fields, cosmic rays.
23	LUNA-23 [SAMPLE RETURN]	28-10-1974	Originally sample return, drilling equipment DAMAGED during landing thus no samples.
24	LUNA-24 [SAMPLE RETURN]	09-08-1976	Sent back 170.1 g of lunar soil.

Overall USSR had 44 launches of which only 17 were successful.

Table 2: Missions launched by US Airforce & NASA (USA) (PIONEER MISSIONS)

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	PIONEER-1	17-08-1958	First stage malfunction, FAILED.
2	PIONEER-2	11-10-1958	Set distance record, FAILED to reach Moon.
3	PIONEER-3	08-11-1958	Third stage unsuccessful, FAILED.
4	PIONEER-4	03-03-1959	Flew past Moon by 60,000 km.

Table 3: Missions launched by US Airforce & NASA (USA) (RANGER MISSIONSⁱⁱ)

S. No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	RANGER-7	28-04-1964	Shot 7000 closeup pictures of the Moon.
2	RANGER-8	17-02-1965	Helped in finding primary landing site for APOLLO missions.
3	RANGER-9	21-03-1965	Directly broadcasted images of the Moon on the television.

Table 4: Missions launched by US Airforce & NASA (USA) (SURVEYOR MISSIONS)

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	SURVEYOR-1	21-05-1966	First US soft landing.

2	SURVEYOR-2	20-09-1966	IMPACTED.
3	SURVEYOR-3	17-04-1967	Visited on Moon by APOLLO-12 crew.
4	SURVEYOR-4	14-07-1967	FAILED.
5	SURVEYOR-5	1967-1968	Performed various soil tests for crew lander missions.
6	SURVEYOR-6		
7	SURVEYOR-7		

Table 5: Missions launched by US Airforce & NASA (USA) (LUNAR ORBITER MISSIONS)

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	LUNAR ORBITER-1	1966-1967	Surveyed the landing site for crew lander mission.
2	LUNAR ORBITER-2		
3	LUNAR ORBITER-3		
4	LUNAR ORBITER-4	1967	Completely mapped the lunar surface.
5	LUNAR ORBITER-5		

Table 6: Missions launched by US Airforce & NASA (USA) (APOLLO MISSIONS)

S.No.	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	APOLLO-8	21-12-1968	First humans to orbit Moon.
2	APOLLO-10	18-05-1969	SUCCESSFUL lander test.
3	APOLLO-11	16-07-1969	First humans on Moon, brought soil and rock samples.
4	APOLLO-12,14,15,16,17	1969-1972	All crew missions were SUCCESSFUL, brought 400 kg samples.
5	APOLLO-13	11-04-1970	Mission ABORTED, crew returned safely.

Overall, USA had 47 launches of which only 24 were successful.

Table 7: Satellites launched by several other countries

S.No.	COUNTRY	NAME	LAUNCH DATE (DD-MM-YYYY)	ACHIEVEMENTS/MISSIONS/STATUS
1	JAPAN	HITEN	24-01-1980	First to implement aerobraking.
2		KAGUYA	14-09-2007	Found gravitational anomalies on near and far side of Moon.
3	EU	SMART-1	27-08-2003	First to perform test on ion drive.
4	CHINA	CHANG'E-1	24-10-2007	First Chinese satellite to Moon.

5		CHANG'E-2	01-10-2010	SUCCESSFUL.
6		CHANG'E-3	06-12-2013	Delivered Chinese rover 'YUTU-1'.
7		CHANG'E-4	07-12-2018	Delivered Chinese rover 'YUTU-2'.
8		CHANG'E-5	23-11-2020	First Chinese sample return mission.
9	INDIA	CHANDRAYAAN-1	22-10-2008	First Indian lunar mission, DISCOVERED water locked in minerals, IMPACTED.
10		CHANDRAYAAN-2	22-07-2019	SUCCESSFUL orbiter, lander CRASHED.
11		CHANDRAYAAN-3	23-08-2023	First Indian soft landing, delivered rover 'PRAGYAAN'.
12	RUSSIA	LUNA-25	10-08-2023	FAILED.

Apart from all these countries various other countries have also attempted lunar missions such as Israel, Luxembourg, South Korea, Italy, UAE. Continuing this race to Moon there are a plethora of mission which would be executed by the end of this decade. These missions include flybys, orbiters, rovers, sample returners and crew lander missions.

Conclusions

The main question that arises is, why do we need to explore the Moon. The answer is it is because of the advantages Moon provides when it comes to deep space exploration as it can be used as a launching site since it has less gravity than Earth (1/6th), also the findings of CHANDRAYAAN-1 showed the existence of water locked in minerals, since water can be separated into Hydrogen and Oxygen which in turn can be used as a fuel.

More than 60 years of Moon exploration have taught humans' various things such as,

- i) Trajectories – Earlier USA and USSR used direct shot method wherein they directly shot the satellite towards the Moon. This method was indeed fast but vastly inefficient. Later, they adapted two stage method, in which they first shot the satellite into Earth's orbit and from there they shot into Moon's orbit. It took more time but this method was more efficient than the former. Currently, India uses the slingshot method, in which we accelerate the satellite in elliptical orbit till it attains enough speed to reach Moon's orbit. It is the slowest but the most efficient method as it consumes the least amount of fuel.
- ii) Autonomous Softwares – Earlier, every operation and maneuver performed by the satellite was precalculated and there were close to none onboard corrections that could be conducted. Now the softwares are capable enough to determine the perfect landing spot as well as provide the necessary commands to maneuver the satellite.
- iii) Hardware Development – Not only the propulsion systems but also the telemetry, photography and navigation systems have been immensely researched and developed.
- iv) Scientific Discoveries – From the discovery of absence of magnetic field around the Moon to the presence of water on the Moon, we humans have discovered a variety of things and more are yet to be discovered.

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