*Chandrayaan 2* is an Indian lunar mission that will attempted to land on the Moon's south polar region, India being the first country to attempt it. Through this effort, the aim was to improve the understanding of Moon, discoveries that will benefit India and humanity as a whole. Though there are a few conventional models, the origin of the Moon still needs further explanations. Mapping of the lunar surface to study variations in lunar surface composition is essential to trace back the origin and evolution of the Moon. Evidence for water molecules discovered by *Chandrayaan-1* requires further studies on the extent of water molecule distribution on the surface to address the origin of water on the Moon.

The idea of the lunar exploration project took birth in the year 2003. On the eve of Independence Day, the then Prime Minister of India, Late Shri Atal Bihari Vajpayee had announced about the space research organization’s new programme *Chandrayaan 1*. With the scientists’ rigorous and dedicated effort, the project was ready in five years. It was on 22nd October 2008, *Chandrayaan 1* took off from Satish Dhawan Space Centre at Sriharikota. The*Moon Lunar Probe* ejected from the launch vehicle and crashed near the lunar South Pole but it confirmed the presence of water molecules on Moon's surface before crashing. With the partial success of the mission *Chandrayaan 1,* many questions about the lunar body were left unanswered.

It was then in 2008, the then Prime Minister of India Dr. Manmohan Singh approved *Chandrayaan 2*lunar mission on the 18th of September. Considering the drawbacks and flaws from the previous mission “Chandrayaan1”, after leveraging nearly a decade of scientific research and engineering development, 22nd July was announced as the launch date for “Chandrayaan2”.

Chandrayaan-2 was designed to soft-land the lander -*Vikram* and rover- *Pragyan* in a high plain between two craters, *Manzinus C* and *Simpelius N*, at a latitude of about 70° south on the lunar surface.

Unique features of *Chandrayaan 2*:

* 1st space mission to conduct a soft landing on the Moon's south polar region.
* 1st Indian expedition to attempt a soft landing on the lunar surface with home-grown technology.
* 1st Indian mission to explore the lunar terrain with home-grown technology.
* 4th country ever to soft-land on the lunar surface.

**How Mission was planned:**

Launcher:

The *GSLV Mk-III* carried *Chandrayaan 2* to its designated orbit. This three-stage vehicle is India's most powerful launcher to date and is capable of launching 4-ton class of satellites to the Geosynchronous Transfer Orbit (GTO). India’s Geosynchronous Satellite Launch Vehicle, *GSLV MkIII-M1* successfully launched *Chandrayaan-2* spacecraft at on July 22, 2019 into its planned orbit. After the injection of *Chandrayaan-2* spacecraft, a series of manoeuvres were carried out to raise its orbit and put *Chandrayaan-2* on Lunar Transfer Trajectory. On entering Moon's sphere of influence, on-board thrusters had reduced the velocity of spacecraft for Lunar Capture. The Orbit of *Chandrayaan-2* around the moon was circularized to 100x100 km orbit through a series of orbital manoeuvres. On the day of landing i.e., the lander separated from the Orbiter on 2nd September 2019 and then had to perform a series of complex manoeuvres comprising of rough braking and fine braking. Imaging of the landing site region had to done before landing for finding safe and hazard-free zones.

At the start of rough braking and fine braking phase, ISRO's ground station lost contact with lander Vikram as it was merely 2.1 km above the lunar surface. However, ISRO said that it is not sure whether the lander crash-landed or not. The space agency added that it is presently analysing the data available with it to ascertain the reason behind the snag and the findings will be made public on a later date. Notably, even though communication with lander *Vikram* and rover *Pragyan* is lost, the Orbiter at a 100km orbit remains functional with eight working science payloads.

Orbiter:

The *Chandrayaan 2* Orbiter is capable of communicating with Indian Deep Space Network (IDSN) at Byalalu as well as the Vikram Lander. The mission life of the Orbiter is one year and it will be placed in a 100X100 km lunar polar orbit.

Lander:

The Lander of *Chandrayaan 2* is named *Vikram* after Dr. Vikram A Sarabhai, the Father of the Indian Space Programme. It was designed to function for one lunar day, which is equivalent to about 14 Earth days. Vikram can communicate with Indian Deep Space Network (IDSN) at Byalalu near Bangalore, as well as with the Orbiter and Rover. The Lander was designed to execute a soft landing on the lunar surface.

Rover:

*Chandrayaan 2's* Rover is a 6-wheeled robotic vehicle named *Pragyan*, which translates to 'wisdom' in Sanskrit. It can travel up to 500 m (½-a-km) and leverages solar energy for its functioning. It can only communicate with the Lander. Rover was designed to probe the lunar surface, study lunar quakes and confirm the information given by *Chandrayaan 1*.

Science Experiments as planned:

*Chandrayaan-2* had several science payloads to expand the lunar scientific knowledge through a detailed study of topography, seismography, mineral identification and distribution, surface chemical composition, thermo-physical characteristics of topsoil and composition of the tenuous lunar atmosphere, leading to a new understanding of the origin and evolution of the Moon. The Orbiter payloads will conduct remote-sensing observations from a 100 km orbit while the Lander and Rover payloads will perform in-situ measurements near the landing site.

For an understanding of the Lunar composition, it is planned to identify the elements and map its distribution on the lunar surface both at global and In-situ level. Thermo-physical property of the lunar surface and seismic activities will also be measured. Water molecule distribution will be studied using infra-red spectroscopy, synthetic aperture radiometry & polarimetry as well as mass spectroscopy techniques.

Having lost the communication with the lander, ISRO has till date failed to establish communication with the lander and rover. Despite the setbacks, the orbiter is perfectly placed in the desired lunar orbit. The mission life of orbiter is one year and it will continue to perform the experiments and send back the data.

Loss of Control:

It was at this point that the third phase, the Fine Braking Speed Phase lasting 90 seconds, began. To bring down *Vikram’s*horizontal and vertical speeds to near-zero and the craft to an altitude of 400 metres, two of the four engines were to shut down. The console showed that the vertical speed had increased, it was at this juncture that all communication with the control room snapped. There was no evidence to show that the two engines out of five had shut down as per plan. All the console showed was that the horizontal velocity was still a high 48 metres per second and the vertical velocity 59 metres per second. Both these key parameters should have been considerably lower for the lander to go into its terminal descent phase. Its speed at this point should have been near-zero and it should have been hovering over the lunar surface at a height of 400 metres. Its onboard cameras were then to take pictures for its control system to check whether the landing site was suitable.

ISRO had decided that *Vikram* would land near the colder South Pole where water molecules were expected to be found in greater abundance. *Vikram’s*control system, using its instruments including the cameras, was to ensure that the craft would land on a flat surface. If it landed on any surface that had an incline beyond 12 degrees, it would topple over. *Vikram* was to then descend to 10 metres before its onboard control system would switch off two engines. The fifth engine located at its base would then be switched on for a controlled descent. All this was to happen if everything had gone well in the earlier phases. But, since communication snapped at a height of 2.1 km, there is no evidence so far to show whether the terminal descent phase was activated or not.

ISRO Chief K Sivan in his statement stated that the lander was in a tilted position and that it was not broken. Keeping hopes alive, he said that efforts are being made to restore the link with the lander. The window of opportunity is said to be 14 days, which is one Lunar Day and ends on September 21, 2019. Given that the mission was highly complex and unique, with several key technologies involved and studying the entire Moon, ISRO has done a commendable job in achieving success in two of the three phases, while almost succeeding in the final phase.

*Chandrayaan-2* Mission has achieved efficiencies in each phase, which has become beneficial by itself. The best example of this is the enhanced life of the Orbiter, which will last nearly 7 years, compared to the expected one year. Whether it is 95 percent or two of the three phases of success, the organization will surely go back to the drawing board and fix the issues. ISRO’s record has been commendable in bouncing back from failures by learning from them and achieving mission success at highly competitive costs and improved performances.

Final Thoughts

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