The Spacecraft of Hopes

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Abstract:

The Chandrayaan-3 moon mission aims to safely land on the moon and conduct scientific experiments on the lunar surface. India's space program, which began in the 1970s, has advanced significantly, with the largest network of remote sensing satellites in the world. Chandrayaan 3, a moon mission launched by the Indian Space Research Organisation (ISRO), aims to develop new interplanetary technologies. Chandrayaan 3's Laser Induced Breakdown Spectroscopy instrument confirmed the presence of sulphur on the moon's South Pole, marking the first in-situ measurement. The instrument uses high-energy laser pulses to measure the elements present in the soil, including sulphur, aluminium, iron, titanium, calcium, and chromium. The oxygen on the moon is found in the soil and rocks, and NASA has extracted oxygen from lunar soil simulant. The Alpha Particle X-ray Spectrometer releases alpha particles and X-rays that interact with the moon's surface, identifying different elements. RAMBHA, a 5 cm wide metallic spherical probe, measures the natural plasma on the moon's surface, measuring approximately 5 to 30 million electrons per cubic meter. All these accomplishments establish Chandrayaan 3 as the pride of India.

Keywords: APXS: *Alpha Particle X-ray Spectrometer;* ***LIBS:*** *Laser Induced Breakdown Spectroscope;* ***SHAPE:*** *Spectro-polarimetry of Habitable Planetary Earth;* ***Propulsion Module:*** *a component or system in a vehicle or spacecraft designed specifically for providing the necessary thrust or propulsion to propel the vehicle forward or maneuver in space.*

1. Introduction:

An occasion of pride and glory for all my fellow Indians, as India's Chandrayaan-3 makes history by landing on the moon's south pole, the first country to reach such a milestone. I believe we were all ecstatic as the Vikram, the mighty lander of Chandrayaan-3, approached the peaceful, desolate and serene surface of the moon. Despite the doubts and criticisms of many economists, even the common man prayed for the success of the lunar mission and looked forward to the developments that lay ahead. "Chandrayaan-3's triumph mirrors the aspirations and capabilities of 1.4 billion Indians," Mr. Modi said when the landing was complete, declaring the event as "the moment for new, developing India" and instilling a feeling of patriotism in everyone.

The mission's goals included a soft and safe landing, rover exploration of the moon, and on-site scientific experiments. Along with conducting tests and examining the lunar surface's thermal characteristics and seismic activity, ISRO also hopes to show off the rover's mobility on the moon. The rover is equipped with two instruments: the Alpha Particle X-ray Spectrometer (APXS) and the Laser Induced Breakdown Spectroscope (LIBS). To assist specialists in learning more about the lunar surface, the former will offer information on the chemical and mineralogical makeup of the lunar surface. The latter will search for materials on the lunar surface and in the rocks surrounding the landing area. Additionally, it is equipped with a device known as Spectro-polarimetry of Habitable Planetary Earth (SHAPE), which makes it possible to find smaller planets. A range of possibly habitable exoplanets can be investigated by scientists with the aid of the reflected light from the smaller planets.

Astronauts have visited the moon, spacecrafts have surveyed the solar system, and space instruments have found thousands of planets orbiting other stars in the years since the first artificial satellite was launched in 1957. The late 20th century saw a rapid increase in space technology that made several astronauts, like Neil Armstrong, Kalpana Chawla, Jhon Glen, and Rakesh Sharma, known to the entire world. President John F. Kennedy established the objective of "landing a man on the moon and returning him safely to Earth within a decade" in 1961. Astronaut Neil Armstrong made "one giant leap for mankind" on July 20, 1969, when he set foot on the moon. From 1969 to 1972, six Apollo missions were conducted to investigate the Moon. Thus, a number of space programs were launched, including Project Mercury, Skylab, Apollo, Gemini, and the Space Shuttle[1]. The list continues as humanity continues to fancy space. As long as people are still fascinated with space, the list will never end.

Being a developing nation, India faces numerous socioeconomic issues that are typically given top priority. Despite this, India's space program has advanced to the point where it is presently unmatched. With experimental satellites like Aryabhatta, Bhaskara, Rohin, and Apple, ISRO got its start in the 1970s. In the 1980s, cutting-edge programs like IRS and INSAT were put into service. With the largest network of remote sensing satellites in the world, India is preparing for independence from outside assistance. Since the first rocket, a satellite launch vehicle, crashed into the Bay of Bengal, the organization has advanced to the point where it is now producing polar and geosynchronous satellite launch vehicles. Not only are Third World countries inspired by the tour, but so are developed nations. ISRO has finally proved it's importance for the Indian economy accomplishing Sri. Vikram Sarabhai's dream as he wished," There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in

[1] https://education.nationalgeographic.org/resource/history-space-exploration/

the exploration of the moon or the planets or manned space-flight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society."

The Chandrayaan-3 moon mission is built on a budget of just under Rs 615 crore or $75 million. Now, one may question the necessity of moon exploration. Well, the moon's ability to serve as a natural laboratory and being almost vacuum are the primary factors fueling human curiosity about it. After all, curiosity is the essence of our existence. India's outstanding scientists at ISRO are driven by curiosity and aspirations for a better future to push the boundaries of human technological capability and enable us to learn more about our solar system through a number of successful space missions, including Chandrayaan, Aditya L1, Mangalyaan, and many others. The most talked-about and well-known space mission at the moment, Chandrayaan 3, is likely the moon mission that is making the Indian flag stand more prominent than ever. The Chandrayaan-3 was launched from the Satish Dhawan Space Centre (formerly Sriharikota Range– SHAR).

It is the primary spaceport of the Indian Space Research Organisation (ISRO) at Sriharikota, Andhra Pradesh. With a mission life of 14 earth days and 1 moon day, Chandrarayan 3 was launched by LVM3 on July 14, 2023, towards the southern high latitudes of the moon. Biggest and heaviest LVM3 rocket (previously GSLV MkIII), frequently called as 'fat boy' by ISRO scientists due to its heavy lift capacity, has successfully completed six missions in a row.

Figure-6: Chandrayaan-3[2]

The propulsion, lander, and rover (which is housed inside the lander) modules combine to form the LVM3 rocket. While the first rocket's first stage is powered by solid fuel, the second stage is by liquid fuel and the third and final stage consists of a cryogenic engine powered by liquid hydrogen and liquid oxygen. The goal of Chandrayaan-3 is to develop and demonstrate new technologies needed for interplanetary missions. During its mobility, the Rover will conduct in-situ chemical analysis of the lunar surface, and the Lander will be able to soft land at a designated lunar site. There are scientific payloads on both the Lander and the Rover to conduct experiments on the lunar surface. The Propulsion module's primary job is to transport the Lander module from launch vehicle injection to the final 100 km circular polar orbit on the moon and then detach it from the Propulsion module. In addition, the Propulsion Module has a single scientific payload that will be utilized after the Lander Module separates.

[2] https://www.isro.gov.in/Chandrayaan3.html

The three primary phases of Chandrayan 3 are the Earth-centric phase (Pre-Launch, Launch and Ascent and Earth-bound Manoeuvre), moon transfer phase (Transfer Trajectory), and moon centric phase (Lunar Orbit Insertion Phase, Moon-bound Manoeuvre Phase). India is the first nation to land on the moon with a cluster engine, which is one of the lander's primary features.

Figure-7: Chandrayaan-3[3]

Many people questioned why India's moon mission was slower as compared to the Russian Luna 25. Well, the extra days it spent in space were spent first building up momentum and, after making several revolutions around the planet (Luna-25 only made one full orbit), slingshotting to the moon and slowing down there. Thus, successfully reaching the moon with less expensive yet cost-efficient rocket fat boy. As our prime minister once said it is really remarkable of India to reach moon with a budget lesser than a western film production cost. The blood, sweat and tears of ISRO's scientists that go into the making the moon mission a success are unmatched. This great achievement couldn't have been accomplished without the immense support and encouragement from the government.

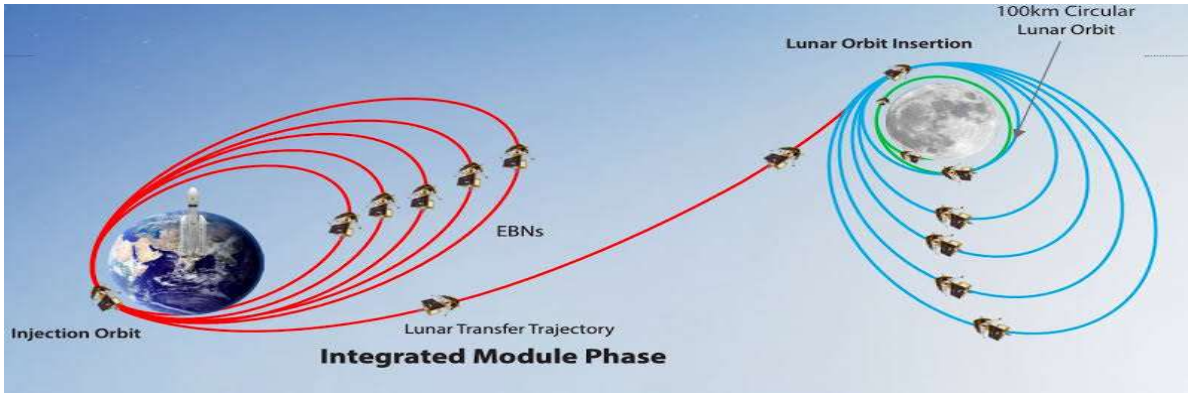

Figure-9: Integrated Module Phase[4]

While many people are talking about the soft landing on the moon, I don't think we are talking enough about the observations and experiments conducted by Chandrayaan 3 on the lunar

[3] https://www.isro.gov.in/Chandrayaan3.html
[4] https://www.isro.gov.in/Ch3_first_observation_ChaSTE_Vikram_Lander.html

surface. Let's talk about the tremendous achievement made by the CHaSTE payload which provides insights into moon's surface. Its job was to measure the temperature of the top soil of the moon to understand how much the temperature varies on moon South Pole. The the temperature was measured by a temperature probe attached on CHaSTE. And there are 10 sensors on CHaSTE . This temperature probe can go 10 cm below the surface of the moon. It was observed here that by going 1 cm below the soil of the moon, the temperature changes by 10 degrees Celsius, the temperature on the surface was almost 60 degrees Celsius, but by probing 8 cm soil, the temperature was −10°C. Such a big te0mperature difference in just 8 cm. This is the first profile made for the South Pole of the moon.

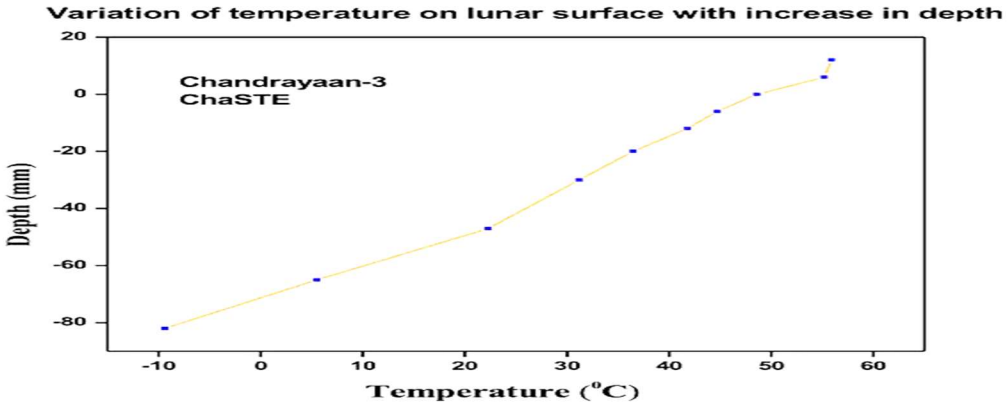

Figure-10: Variation of Temperature on Lunar Surface with Increasing in Depth[5]

On august twenty-eight LIBS that is Laser Induced Breakdown Spectroscopy instrument confirmed the presence of Sulphur on the South Pole of the moon, Establishing this achievement as the first ever in-situ measurement on the moon. This Instrument uses high energy laser pulses. A high temperature laser is focused and targeted at a small area of the soil on the moon. The soil there, due to this high temperature, gets converted into plasma. And our instrument here measures the different wavelengths of light. And based on that, it can identify. The elements present in the soil of the moon. Not only Sulphur but also aluminium, iron, titanium, calcium, chromium has been observed on the lunar surface by Chandrayaa-3. The presence of sulphur on the moon have already been detected by Russian and American moon missions in the 1970's, but Chandrayaan's in-situ finding is the very first definite discovery of Sulphur. You might be astonished at oxygen being present on the moon. This oxygen is actually present in the soil and rocks of the moon. There is No atmospheric oxygen present on the moon, but oxygen does exist in the form of bonds with different elements present in the lunar soil. This oxygen can be extracted and used as NASA has successfully extracted oxygen from lunar soil simulant on 25th

[5] https://www.isro.gov.in/LIBSResults.html

April 2023. Its amount is so huge that it is said that the oxygen in the top soil of the moon is enough to sustain eight billion people for 100,000 years.

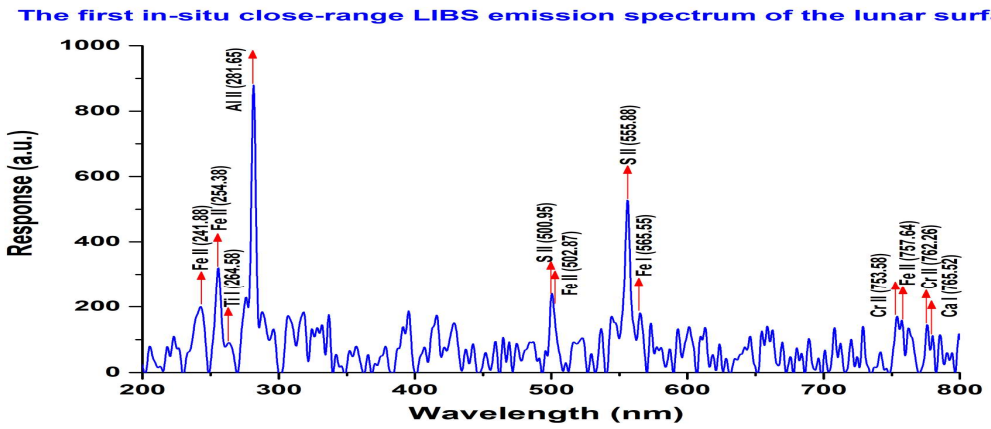

Figure-11: LIBS Emission Spectrum of the Lunar Surface[6]

Another payload called the APXS, Alpha Particle X-ray Spectrometer, consists a small radioactive source releasing alpha particles and X-Rays which interact with the moon's surface. The electrons of the materials present on the surface are released and they start emitting their own X-rays which are then observed by the APXS detectors to identify different elements.

APXS is developed by the Physical Research Laboratory (PRL), Ahmedabad with support from the Space Application Centre (SAC) Ahmedabad, whereas UR Rao Satellite Centre (URSC), Bengaluru has built the deployment mechanism.

Now coming to the payloads of Vikram lander, RAMBHA. It measures the natural plasma that is already present on the moon. This instrument is a 5 cm wide metallic spherical probe which is placed on a pole at the height of 1 meter on Vikram's upper deck.

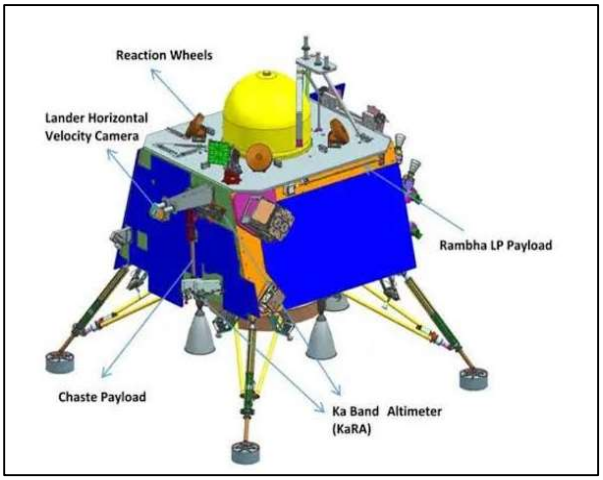

Figure-12: Payloads of Vikram Lander[7]

Even though there is no atmosphere, a minute amount of plasma naturally exists on the surface of the moon AND RAMBHA detected this. Approximately 5 to 30 million electrons per cubic

[6] https://www.isro.gov.in/APXS.html
[7] https://www.isro.gov.in/Ch3_Rambha-LP_near-surface_Plasma.html

meter of plasma is present on the lunar surface. It is So little that ISRO has defined it as being 'relatively sparse' and is measured in Pico amperes by RAMBHA. The voltage is passed through the probe and the current that returns is measured identifying the densities of ions and electrons in lunar plasma. This tells us that radio waves can propagate easily on the moon without much interruption. These findings would be useful to create such designs with which communication can be made easier.

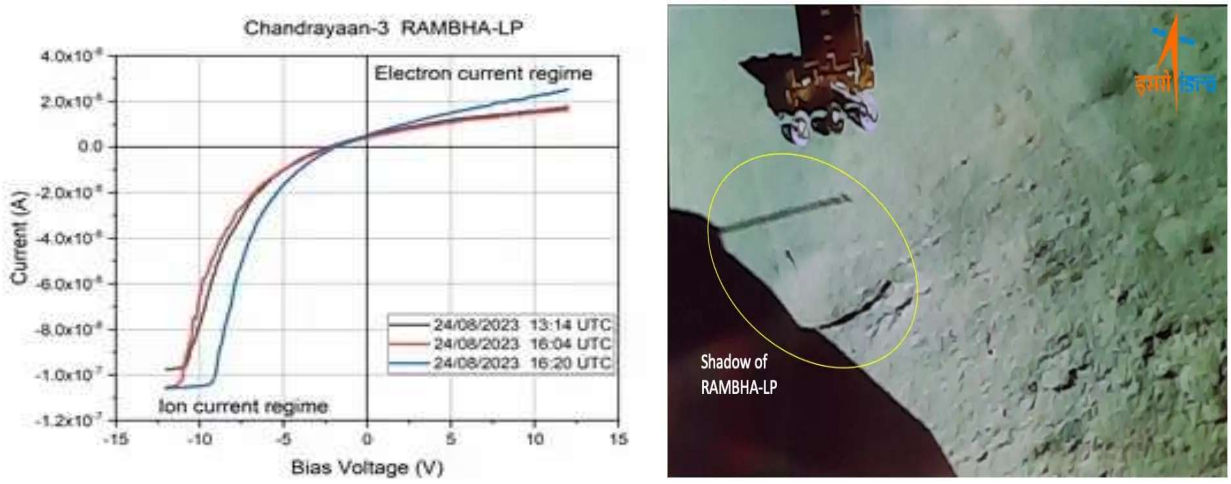

Figure-13: Chandrayaan -3 RAMBHA-LP[8]

ILSA's findings were also shared by ISRO on 31st August. ILSA, Instrument for Lunar Seismic Activity, is the first payload to use Micro-Electro Mechanical Systems technology on the moon. This technology was used to record vibrations. When the Pragyan rover started moving on the moon's surface, those vibrations were also recorded by ILSA. The moon quakes observed by ILSA helps us to get a better understanding of the interior of the moon.

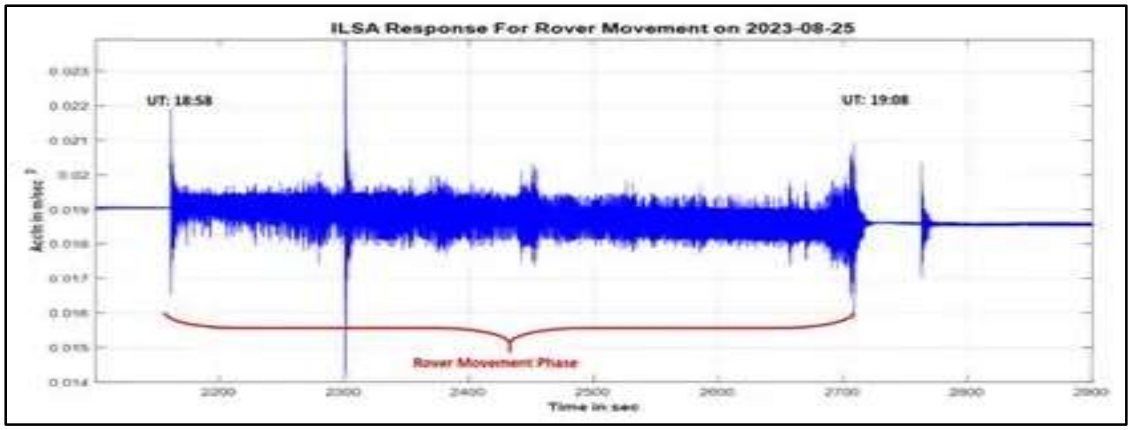

Figure-7: ILSA Response for Rover Movement on 25.08.2023

[8] https://www.isro.gov.in/Ch3_ILSA_Listens_Landing_Site.html

Chandrayan 3's rover pragyan and lander Vikram put to sleep on the moon. ISRO is hoping for a successful awakening when the lunar day starts at the South Pole again. On September 22 ISRO stated through their official website that efforts to establish communication with lander and rover are underway. The mission was designed to function for one lunar day or about 14 days on Earth, but the electronics on the rover and lander are not designed to survive the extreme night-time conditions on the Moon. The space agency has not been able to make contact with the mission, and the chances of reawakening are dimming with each passing hour. The Chandrayaan-3 mission is still a huge success even though it didn't wake up after its lifetime.

The Gaganyaan[9] project aims to demonstrate human spaceflight capability by launching a crew of three to an orbit of 400 km for three days and safely landing them in Indian sea waters. The project will utilize in-house expertise, Indian industry experience, and cutting-edge technologies from international agencies. Pre-requisites include developing critical technologies, demonstrating technology preparedness, and proving safety and reliability in unmanned missions.

Astronomical emission mechanisms from sources like blackholes, neutron stars, and pulsar wind nebulae are complex and challenging to understand. Polarimetry measurements provide valuable insights into the degree and angle of polarization, making them an excellent diagnostic tool. The Indian science community is focusing on polarimetric observations and spectroscopic measurements to break the degeneracy of theoretical models. POLIX, an X-ray Polarimeter developed by Ramam Research Institute and U R Rao Satellite Centre, is expected to observe about 40 bright sources during its 5-year mission. XSPECT, an X-ray SPECtroscopy and Timing payload, can provide fast timing and good spectroscopic resolution in soft X-rays. Both payloads aim to provide long-term monitoring of spectral state changes, line flux, and profile changes in continuum emission.

NASA and ISRO are partnering to develop a dual frequency radar imaging mission using advanced Sweep SAR techniques[10]. The mission will provide high repeat cycle, high resolution, and larger swath data for L & S band space-borne SAR data. The mission will help disentangle and clarify complex phenomena, such as ecosystem disturbances, ice sheet collapse, and natural hazards. The precision interferometric orbits will enable mapping of deformations in land surfaces and better characterization of vegetation. The mission will also enable characterizing targets beneath tree canopy and sub-surface features. The Synthetic Aperture Radar mission will monitor ocean changes, shoreline erosion, and sea ice characteristics, potentially detecting marine oil spills and promoting preventive measures.

[9] https://www.isro.gov.in/Gaganyaan.html
[10] https://www.isro.gov.in/XPoSat.html

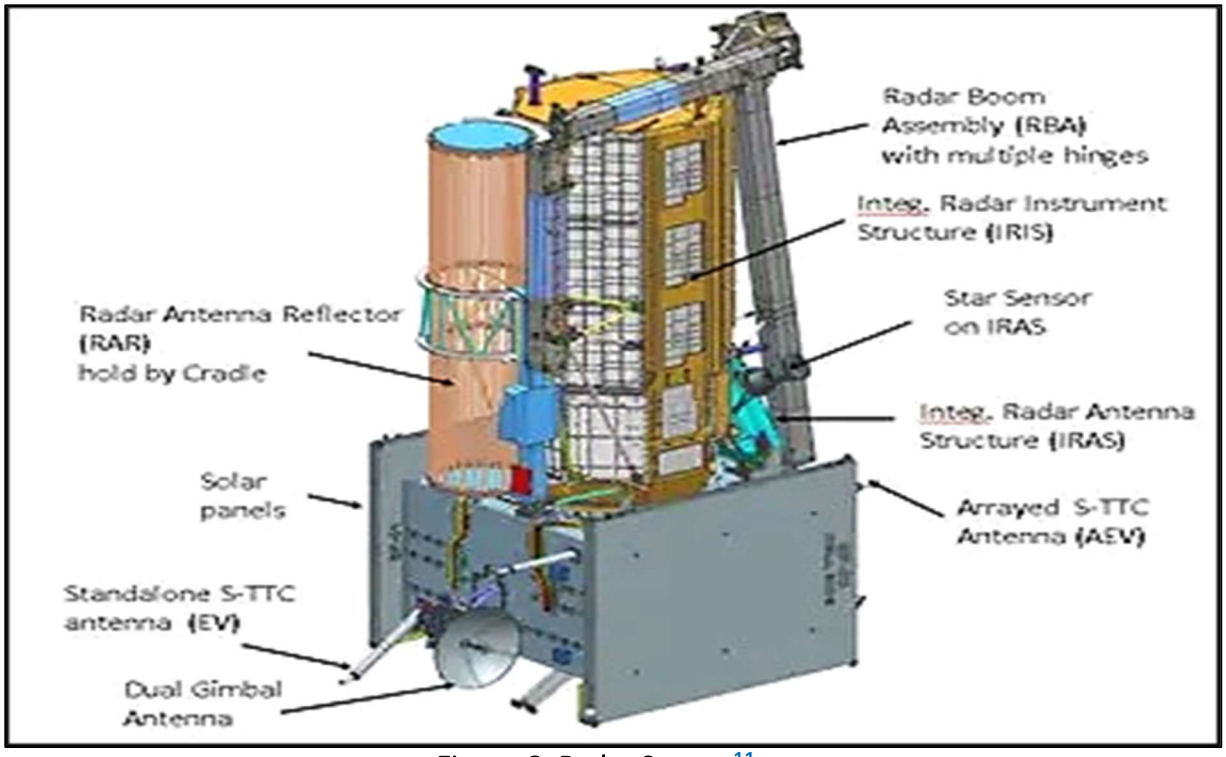

Figure-8: Radar System[11]

Following the 2021 COVID-19 pandemic, a large portion of the world experienced shortages and higher prices in the markets for oil, gas, and electricity, which marked the beginning of the 2021–2023 global energy crisis. The crisis was brought on by a number of economic factors, such as the quick recovery from the pandemic that exceeded the availability of energy, and it intensified into a global energy crisis after Russia invaded Ukraine. Natural gas prices surged to all-time highs, which in turn caused electricity prices to rise in certain markets. The price of oil reached its highest point since 2008.In the face of such a crisis, our natural satellite can help us out. In recent decades, science fiction and reality have been stimulated by the idea of harvesting a clean and efficient form of energy from the Moon. The lunar surface has experienced a significant amount of Helium-3 bombardment from the solar wind, in contrast to Earth, which is shielded by its magnetic field. Because this isotope is not radioactive and would not produce hazardous waste products, it is believed to offer safer nuclear energy in fusion reactors. So, the next space mission should be the extraction of Helium-3 in my opinion. This would solve the world energy deficit to a great extent. Many other materials which are less abundant on earth can be extracted by lunar mining satisfying the growing needs of the population.

[11] https://www.isro.gov.in/XPoSat.html

A rare moment of unanimity in a nation with a long history of science was created by the excitement and anticipation around the landing. The live stream of India's Chandrayaan-3's soft landing on the moon by ISRO has set a new record on YouTube, with over eight million concurrent viewers, making it the highest viewership in YouTube history. The live-streaming event included a captivating 16-second clip, providing viewers with glimpses of ISRO's mission control center in Bengaluru. This clip offered a comprehensive view of the entire journey, from the commencement of the broadcast to Chandrayaan-3's successful landing, while also showcasing the jubilation and celebrations among the ISRO staff. I hope the scientists at ISRO will bring more such opportunities for us in the near future. I could not believe that a common man who is not interested in space, stopped on the way to cheer for ISRO because this the victory of every Indian who believes we are worthy of greatness.

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