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CHANDRAYAAN-3: UNRAVELLING THE MYSTERIES OF CELESTIAL CHOREOGRAPHY

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ABSTRACT:

This research paper, "Chandrayaan-3: Unveiling the Mysteries of Celestial Choreography", explores various Missile types and their roles. It highlights the remarkable contributions of the Indian Space Research Organisation (ISRO) and our scientists in science and technology, particularly concerning the Chandrayaan-3 mission. The study emphasizes the significance of the three crucial phases of orbit from Earth to the Moon. Specifically, it sheds light on the upcoming crewless lunar mission, LVM3-M4-Chandrayaan-3, which aims to uncover the origin and evolution of the Moon. Furthermore, this mission's advancements are poised to enhance our ability to probe the planet Mars shortly.

Keywords: Satellite, Payloads, Mission, Alpha Particle X-ray Spectrometer, Spectro-Polarimeter, Payload.

INTRODUCTION:

In the cosmos, the term "satellite" encompasses various celestial entities, ranging from moons and planets to manufactured machines, all revolving around a central celestial body like a planet or star. To illustrate, our Earth qualifies as a satellite as it orbits the Sun, while the Moon serves as Earth's satellite due to its orbit around our planet. Generally, when we use the term "satellite," we often refer to a precisely engineered apparatus launched into space, designed to orbit either the Earth or another celestial body.

Numerous artificially crafted satellites are in orbit around Earth, each serving diverse purposes. Some are equipped to capture detailed images of our planet, aiding meteorologists in predicting weather patterns and monitoring phenomena such as hurricanes. Conversely, certain satellites are configured to photograph distant planets, the Sun, enigmatic black holes, elusive dark matter, or galaxies several light-years away. Such visual data is pivotal in advancing our understanding of the solar system and the more expansive Universe.

In contrast, Earth's natural satellite is the Moon, although it is not the largest one within our solar system. Measuring approximately 3476 kilometers in diameter, the Moon is a frigid celestial body composed of rock. Unlike the Sun, it does not emit light on its own accord but instead gleams by reflecting sunlight that strikes its surface.

MISSILES:

When "Missiles" is mentioned, most individuals envisage a towering, slender, circular vehicle. Missiles soar through the sky, albeit not akin to airplanes or choppers. They are crafted to traverse through space utilizing propulsion from one or more missile engines.

KINDS OF MISSILES:

A variety of missiles exist, ranging from diminutive modules like balloon missiles space missiles such as the colossal Saturn V, and so forth.

MISSILES AND MISSILE ENGINES:

Missiles are notably swifter and more forceful. They can ascend vertically with such vigor that they penetrate the atmosphere into outer space. Missile engines operate per Newton's principle, signifying that for every action, there exists an equal and opposite reaction.

COMPONENTS OF MISSILES:

The components of a missile encompass the tip cone, the propelling system, and directional fins. The tip cone accommodates the payload; the propelling system is liable for motion, while the fins regulate the orientation of the missile.

SURVEILLANCE OF THE PLANET:

Missiles serve as ideal spacecraft for Earth observation. They revolve around the Earth, capturing images that offer insights into its surroundings. Some reflect television and telephone signals to Earth.

ORIGINS OF MISSILES IN SCIENCE:

Contemporary missiles are remarkable products of human resourcefulness, with their origins deeply embedded in the science and technology of the bygone era. Centuries ago, missiles were conceived in China with the creation of fireworks. The initial missiles were fashioned akin to arrows and were not particularly potent.

EVOLUTION OF MISSILES:

The earliest utilization of genuine missiles can be traced back to 1232. In 1926, Robert H. Goddard initiated the first liquid-propellant missile, which was subsequently employed in space exploration. Crafted by Alexander Lippisch as a glider, the ENTE marked the inaugural crewed aircraft propelled by rocket power utilizing basic gunpowder missiles in 1928.

THE ERA OF COSMOS:

The efforts of three innovative scholars, Konstantin Tsiolkovsky, Dr. Rocket Goddard, and Dr. Herman Oberth, envisioned the missile as a practical method of human conveyance into the cosmos and developed ideas such as liquid fuel propulsion, missile staging, and crewed celestial stations which eventually precipitated the era of cosmos.

FUNCTIONING OF MISSILES:

In a missile, fuel undergoes combustion in oxygen within a combustion chamber to generate a mass of heated gases that expands and streams backward out of the missile. Subsequently, a counteractive force in the opposing direction, known as "THRUST," propels the missile forward. **COSMIC VESSEL:**

A cosmic vessel, also recognized as a spaceship, is devised to encircle the Earth or voyage through the solar system. Cosmic vessels are propelled into space by exceedingly potent missile engines. They can investigate various entities in the expanse.

SPACE EXPLORER:

A space explorer is an unmanned apparatus dispatched to survey the cosmos. An explorer might operate far into space, or it might circle or touch down on a planet or a moon. It might undertake a unidirectional expedition, or it might return samples and data to the Earth. Most explorers relay data from space via radio in a procedure termed telemetry. Space explorers have assisted scientists in acquiring information about our solar system.

THE COSMIC TRANSPORT:

The cosmic transport is arguably the most intricate mechanism ever constructed by humankind. It signifies a significant leap in technology into the realm of reusable cosmic vehicles. The cosmic transport served as NASA's celestial transportation system, ferrying astronauts and cargo to and from Earth's orbit. The critical components of cosmic transport include the orbiter, the external tank, and the solid missile boosters.

DISCOVERING THE COSMOS:

Missiles propelled humans into space and materialized the exploration of the Moon. Cosmic exploration furnished us with insights into the genesis of our solar system, our planet Earth, and our origins. The era of the cosmos commenced on October 4, 1957, with the launch of the satellite Sputnik 1.

SPACE SOJOURN:

Any instance when an astronaut exits a vehicle while in space is termed a space sojourn. A space sojourn is also referred to as an EVA (extravehicular activity). The first person to embark on a space sojourn was Alexei Leonov, a Russian astronaut. The inaugural space sojourn transpired on March 18, 1965, lasting for 10 minutes.

CELESTIAL STATION:

A celestial station is a substantial satellite equipped to sustain a human crew, intended to linger in orbit around Earth for an extended period, serving as a base for launching exploratory expeditions, conducting research, repairing satellites, and more.

CREW EXPLORATION MODULE: The Crew Exploration Module (CEM) is a novel spacecraft for human cosmic exploration capable of transporting crews of three astronauts and supplementary cargo to and from the international space station. It possesses the capability to accommodate up to six crew members.

EARTH PRECEDES ALL:

The Moon is believed to have taken shape nearly 4.5 billion years ago, not long after Earth. Despite several theories concerning its origin in the past, the currently most widely accepted explanation suggests that the Moon formed from the debris left over after a colossal collision between Earth and a Mars-sized entity named Theia.

INTERNAL CONFIGURATION:

The Moon consists of a distinct crust, mantle, and core. Its core constitutes a minute portion of the total mass and measures roughly 680 km in width. It primarily comprises iron but might also contain substantial amounts of sulphur and other elements. The rocky mantle, about 1,330 km thick, is composed of dense rocks abundant in iron and magnesium. The upper crust, approximately 70 km in depth, has been fractured due to numerous impactful events, resulting in a fragmented zone that gives way to intact material below a depth of around 9.6 km.

LUNAR ATMOSPHERE:

The Moon possesses an exceedingly tenuous atmosphere, allowing layers of dust to settle undisturbed for centuries. Due to the lack of a substantial atmosphere, heat is not retained near the surface, leading to significant temperature fluctuations. Temperatures fluctuate between 134^0C to -153^0C.

GRAVITATIONAL FORCE:

The Moon exerts a considerably weaker gravitational force compared to Earth, owing to its lesser mass, resulting in an individual weighing approximately one-sixth (16.5%) of their weight on Earth.

THE VOYAGE TO THE LUNAR SURFACE AND BACK IN THE APOLLO MISSION:

1. Distinct crew and payload craft are launched from Kennedy Space Centre. The Crew exploration vehicle links up with the lunar lander and Earth Departure stage.
2. The Earth Departure Stage ignites and is discarded, propelling the astronauts toward the Moon. Upon lunar arrival, the lunar lander separates and descends to the surface while the Crew Exploration Vehicle remains in orbit.
3. Following a week on the surface, the upper portion of the lunar lander, or ascent stage, takes off.
4. The lunar lander will accommodate four astronauts, two more than in each Apollo mission.
5. The Astronauts reunite with the Crew Exploration Vehicle. They discard the lunar lander and set course back to Earth aboard the CEV.
6. Unlike Apollo, the crew capsule is expected to land on terra firma at one of 3 locations in the Western United States.
7. The potential touchdown spots are Moses Lake, Carson Flats, and Edwards Air Force Base.

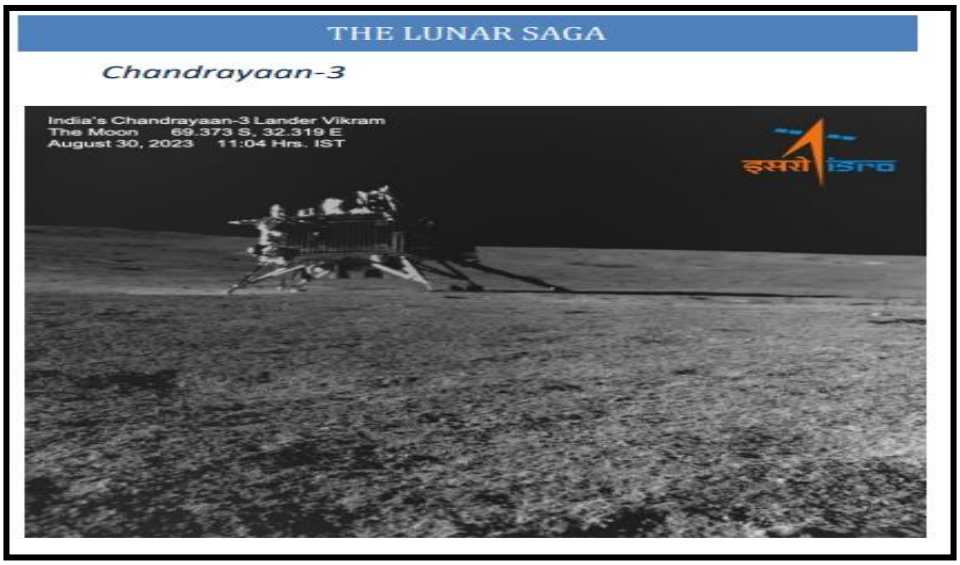
KEPLER'S PRINCIPLES:

A satellite remains in orbit because Earth's gravitational attraction counteracts the outward force from its rotation around Earth. In the early seventeenth century, while examining the Laws of Planetary motion (i.e., the motion of planets and their celestial bodies known as moons), German astronomer Johannes Kepler (1571-1630) revealed the principles that regulate satellite movement. The Laws of planetary motion delineate the shape of the orbit, the velocities of the planet, and the distance a planet maintains concerning the Sun. Kepler's Laws can be succinctly stated as follows: (1) the planets move in an ellipse with the Sun at one focus, (2) the line joining the Sun and a planet covers equal areas in equal intervals of time, and (3) the square of the time taken by a planet to complete one revolution divided by the cube of its average distance from the Sun yields a constant value for all planets.

THE CHRONICLES OF THE MOON

On August 23, 2023, a Wednesday at 6:04 p.m. IST, India's Chandrayaan-3 mission achieved a seamless descent, gently landing on the lunar surface. The intricate coordination between the lander and rover culminated in a carefully orchestrated powered descent, delicately touching down on the predetermined landing coordinates at 69.3 degrees S, 32.3 degrees E. This significant accomplishment propels India to an esteemed league, alongside Russia, the United States, and China, as the fourth nation to master the art of a gentle lunar landing.

The esteemed Prime Minister of India christened the Chandrayaan-3 landing site as 'Shiva Shakti point' and designated August 23 as 'National Space Day' to honor the remarkable achievement of the soft landing of Chandrayaan-3. Furthermore, the location where the Chandrayaan-2 lander faced a hard landing was officially named 'Tiranga.'



Source: https://spacenews.com/chandrayaan-3-success-to-boost-indias-space-ambitions-global-standing/

The selection of Chandrayaan-3's landing site was a result of meticulous analysis, drawing insights from various datasets obtained from previous lunar missions. These datasets incorporated findings from Chandrayaan-1, Chandrayaan-2, Selene, and the Lunar Reconnaissance Orbiter (LRO) mission. Critical factors such as topography, slope, illumination, and hazard avoidance were thoroughly examined to determine the ideal landing site. Each aspect was meticulously assessed, leading to the careful designation of the site.

EARTH'S SATELLITE:

The Moon is the sole natural satellite of Earth. Although not the most significant natural satellite in the solar system, it is the most substantial among the satellites orbiting significant planets.

NASA Picks Plans for Lunar Missions Tests exploring general relativity, ancient cosmos, solar gusts, and Earth-Moon Relationships were opted for by NASA as potential endeavors to be positioned on the lunar exterior. Chosen as a component of the US Program to send people back to the Moon, two of the four types of research include enhancements of the laser reflector array that the Apollo 11 astronauts positioned on the Moon in 1969.

Douglas Currie, a retired professor of physics at the University of Maryland who collaborated on the Apollo 11 tool, is working together with experts at the National Institute of Nuclear Physics at Frascati in Italy to design a new, more extensive array that will deliver more precise ranging data than the current lunar instruments. Meanwhile, Stephen Merkowitz of NASA's Goddard Space Flight Center in Maryland intends to place extra arrays at the polar location of the planned human settlement. These instruments would search for discrepancies in the equivalence principle, which stipulates that the Earth and Moon descend towards the Sun at the same pace, and supply data on the internal composition of the Moon and Earth-Moon connections.

The third concept would deploy small radio telescopes embedded in thin layers of polyamide plastic, which would be rolled up during the journey to the Moon and then unfurled on the Lunar surface. Chief investigator Joseph Lazio of the Naval Research Laboratory in Washington envisions starting with a single, small telescope, consisting of a 500 m-long arm arranged in a Y shape, to analyze solar emissions. Researchers would then follow up with an array of larger telescopes distributed over an area of at least several hundred kilometers to enable them to observe the ancient Universe.

Lastly, Michael Collier of Goddard Space Flight Center and Steven Semblay of Leicester University in the UK propose constructing an X-ray telescope weighing as light as 20 kg to examine how solar wind interacts with both Earth's magnetic field and the Moon's sparse atmosphere.

LVM3-M4/CHANDRAYAAN-3:

India's most prominent and heaviest launch vehicle, LVM3-M4, was launched on Friday, July 14, 2023. Chandrayaan-3, India's crewless lunar mission, aims to achieve a soft and secure landing on the lunar surface from the second launch pad of the Satish Dhawan Space Centre in Sriharikota. With myriad aspirations, Chandrayaan-3 is off by the Indian Space Organization (ISRO), which has been working on the ambitious project since 2020. LVM3-M4 has propelled the 3900-kg Chandrayaan-3 spacecraft, inclusive of the lander, into the Geo Transfer orbit after it took off from the second launch pad.

Touted as a follow-up mission to Chandrayaan-2, which faced failure after the lander crash-landed on the Moon 48 days after its launch in July 2019, Chandrayaan-3 demonstrates end-to-end landing and roving capabilities. The spacecraft took approximately 40 days to softly land on the lunar surface on August 24, eight days faster than the Chandrayaan-2 mission.

Drawing lessons from the failure, the ISRO has made numerous modifications to the Chandrayaan-3 mission, with officials attributing the 2019 failure to the malfunctioning of the onboard computer and propulsion system. This time, the lander's legs have been reinforced, a fifth engine has been removed to decrease weight, and the landing area has been expanded from 500m×500m (in Chandrayaan-2) to 4km×2.4km in Chandrayaan-3.

The Chandrayaan-3 mission is yet another endeavor to accomplish the goal with the aid of a rover. The spacecraft, according to officials, has four payloads that will examine moonquakes, how heat flows through the lunar surface, and the plasma environment near the Moon's surface, and enable scientists to measure the distance between Earth and the moon "with utmost precision."

In the mission sequence, the mission phases are classified into three: Earth Centric (Phase-1), Lunar Transfer Phase (Phase-2), and Moon Centric Phase. The Chandrayaan-3 consists of an indigenous propulsion module, a lander module, and a rover to develop and demonstrate new technologies required for interplanetary missions. The propulsion module will transport the lander and rover from the injection orbit to the 100 km lunar orbit; it also carries a Spectro-polarimetry of Habitable Planetary Earth (SHAPE) payload to study the spectral and polarimetric measurements of Earth from the lunar orbit. The main function of the propulsion module is to carry the LM from the launch vehicle's injection orbit to the lander's separation.

The Gaganyaan Service Module Propulsion System (SMPS). The SMPS performs orbit injection, circulation, on-orbit control, deboost maneuvering, and Service Module-based abort, if any, during the mission's ascent phase. While the LAM engines provide the main propulsive force during this phase, the reaction control system (RCS) thrusters ensure precise altitude correction.

FAT BOY LAUNCHES INDIA'S THIRD MOONSHOT

Mark-111-M4 (LVM3-M4) Missile, nicknamed 'Fat Boy' by space scientists for its capability to transport heavy payloads, is the operational heavy-lift launch vehicle that carries the rover module. After separating from the propulsion module, the mission softly landed the lander module carrying the rover near the lunar south pole. On landing, it deployed the rover to conduct on-site scientific experiments on the lunar surface for 14 days (1 lunar day). The soft landing was executed on August 24, 2023. The LVM3-M4 of ISRO boasts a "pedigree of completing six consecutive missions." This is the fourth operational flight of LVM3 and was launched from the second launch pad (SLP), as per ISRO. Approximately 16 minutes after launch on Friday, July 14, 2023, the propulsion module had detached from "Fat Boy," and the earth-centric mission phase had commenced. During this phase, over the subsequent days, the propulsion module (with the lander carrying the rover attached to it) completed five progressively larger elliptical orbits around the Earth, with the final orbit's farthest point being 36,500 km and its closest point to Earth being 170 km. The strategy is to utilize the Earth's gravity as a slingshot multiple times to gain momentum for its 384,400 km journey to the Moon and be captured by lunar gravity.

In the sixth circle—the launch path—it was propelled onto a path toward the Moon before the Moon's gravitational pull took effect. Upon entering the Moon's gravitational field, the propelling component completed seven revolutions, gradually descending until it settled into a circular polar course 100 km above the Moon's surface. At this point, it deployed the lander, which utilized sensors to identify a suitable touchdown site, enabling a gentle landing near the lunar south pole. The primary role of the propulsion unit is to transport the lander until its separation for a smooth touchdown. However, the propulsion module also carries a payload known as the Spectro-polarimetry of Habitable Planet Earth (SHAPE) for studying the spectral and polarimetric measurements of the Earth while in lunar orbit.

Successfully achieving a soft landing in the Chandrayaan-3 mission would signify redemption for ISRO following the failed attempt during the Chandrayaan-2 mission on September 7, 2019, when the Vikram lander crashed while trying to touch down. Furthermore, India became the fourth country to successfully land a spacecraft on the Moon, following the United States, the former Soviet Union, and China. India's achievement in landing near the Moon's south pole marked a significant milestone, as this previously unexplored region is crucial for future crewed lunar missions due to the abundance of water, ice, and minerals.

LANDER EQUIPMENT:

Chandra's Surface Thermophysical Experiment (ChaSTE) for measuring thermal conductivity and temperature. Instrument for Lunar Seismic Activity to monitor seismic activity around the landing site. Langmuir Probe (LP) for estimating plasma density and variations. A passive Laser Retroreflector Array from NASA for lunar laser ranging studies.

ROVER EQUIPMENT: Alpha Particle X-ray Spectrometer (APXS) and Laser Induced Breakdown Spectroscopy (LIBS) for determining the elemental composition of the landing site.

PROPULSION MODULE EQUIPMENT: SHAPE payload for studying spectral and polarimetric measurements of Earth from lunar orbit.

Focusing on the origin and evolution of the Moon, the Chandrayaan-3 mission aims to thoroughly explore the lunar surface, investigate the electrically charged particles in the lunar atmosphere, and search for moonquakes to uncover new insights into the Earth's only natural satellite.

The designated touchdown area, situated 650 km from the lunar south pole, presents a unique challenge, with temperatures dropping to below minus 230 degrees Celsius. Five instruments aboard the Vikram lander and rover have conducted experiments for 14 Earth days, equivalent to one lunar day, beyond which ISRO does not expect the devices to function. The space agency has taken extensive precautions to ensure the survival of these sensors and the completion of the required experiments.

The rover will carry out two experiments that have never been conducted before. The first involves studying the components of the regolith (planetary surface), while the second focuses on examining the behavior of the ionized atmosphere during day and night. "ISRO chairman S Somnath said, "We will also have instruments to examine the electrical and thermal characteristics of the regolith and moonquakes. The rover will conduct an atomic evaluation of the surface using two instruments."

Considering that the Indian mission precedes NASA's Artemis Program, which aims to send human astronauts close to the lunar south pole, the data gathered from the Indian mission can offer vital insights for planning the first human space flight to the satellite in 50 years.

While all the samples returned from the Apollo missions originate from the Moon's equatorial region, limited data exists from the polar regions. Scientific studies suggest that highland compositions are more diverse than those represented in the samples returned. "The mission aims to evaluate the minute charged atmosphere, ascertain the mineralogy and low-level seismic activity, map the surface, and explore the subsurface. Such data will be

instrumental in determining the possibility of human habitation on the Moon," said astrophysicist Somak Raychaudhury, Vice Chancellor of Ashoka University.

Meanwhile, India is in discussions with Japan for the next Chandrayaan mission, although an agreement has yet to be reached.

CONCLUSION:

Humans have set foot on the Moon, satellites have facilitated the conquering of distances on Earth, and space probes have expanded our understanding of other planets in the solar system. Nevertheless, some grand ambitions still need to be fulfilled. Scientists have long been striving to realize the dream of establishing a base on the Moon or Mars. Although no one has returned to the Moon since 1972, the first operated base could become operational by 2050. Individuals at the initial Lunar base will be involved in mining minerals on the Moon. Many countries are now promoting space tourism, with the first space tourist being Dennis Tito. After the Moon, our next destination will be the red planet, Mars.

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