MISSION PROPOSAL

Investigating the Origin of the Moon through Surface Measurements

<u>Submitted by</u>

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1. Mission Summary

The proposed mission seeks to investigate the origin of the moon by conducting surface measurements using a chipsat placed in a stationary position on the lunar surface. The chipsat will be equipped with various instruments to measure the moon's surface properties, including temperature, magnetic fields, radiation, gravitational fields and mineralogy. Over a period of 2 lunar days, the chipsat will conduct a series of measurements to capture a comprehensive view of the moon's properties. The results from this mission will provide new insights into the origin of the moon and the early solar system, which will have significant implications for our understanding of the formation and evolution of our own planet and the larger universe. This mission is a significant step towards unraveling the mysteries of the moon's formation and will provide crucial data for future lunar exploration and scientific research.

2.1 Scientific Section

The giant impact hypothesis is the most famous theory about the origin of the moon. It proposes that the Moon was formed from debris generated by a collision between Earth and a Mars-sized object around 4.5 billion years ago. This theory is supported by various pieces of evidence, including the Moon's composition, which is similar to Earth's mantle, and its inclined orbit relative to Earth's equator. William K. Hartmann and Donald R. Davis proposed this theory in 1975 in the journal Icarus, and since then, many other studies have provided additional support for this theory. Computer simulations of the impact have shown that the debris would have formed a disk that was similar in composition to the Moon, and the Moon would have formed within a few thousand years.

Despite the giant impact hypothesis being the leading explanation for the Moon's formation, some questions remain unanswered. For instance, why the Moon's composition is so similar to Earth's mantle and why its orbit is inclined relative to Earth's equator. Nonetheless, these questions continue to drive research in planetary science and astrophysics, and with new missions such as the proposed one that aims to investigate the origin of the Moon through surface measurements using a LunaSat lying stationary on the Moon, more insights into the Moon's formation and early solar system could be uncovered.

The scientific goals for this mission can include the following:

1. Understanding the moon's formation: By studying the surface properties of the moon, including its mineralogy, temperature, and magnetic fields, we can gain a better understanding of its formation and evolution. This information can help us verify or refine existing theories of the moon's origin.

2. Determining the moon's composition: Measuring the chemical and physical properties of the moon's surface can help us determine its composition, which in turn can provide clues about its formation and history.

3. Investigating the early solar system: The moon is believed to have formed during the early stages of the solar system, and studying its properties can provide insights into the conditions and processes that were present at that time.

4. Understanding lunar geology: Studying the moon's surface can help us understand its geology, including the formation of craters, volcanoes, and other geological features. This information can provide insights into the moon's history and evolution.

2.2 Technical Section

The chip sized LunaSat is Arduino based satellite which contains a number of sensors, microcontroller, solar power and RF communication system. The sensors will be divided into primary and secondary sensors based on priority of operation in case of power shortage.

1. **Primary Sensors**

   1.1 Magnetometer

   The magnetometer is a Hall Effect sensor that measures magnetic fields in three orthogonal axes. It works by measuring a change in voltage that is proportional to the magnitude of the magnetic field. Our Magnetometer is a *Vector Magnetometer*, meaning it can measure both the direction and magnitude of the local magnetic field. The significances of measuring magnetic field on the Lunar surface are:

   - Can give us insights into the history of geology on the Moon, and how different elements ended up in the Lunar core
   - Give us an understanding of the composition of the Lunar regolith and how it interacts with electronics and magnetic fields
   - The Earth's magnetic field and the Lunar magnetic field interact with each other. Distributed science measurements on the Lunar surface can better inform us of the physics of our own system

   This will lead us to a better understanding of the Lunar environment, which will pave the way for future missions

   1.2 Accelerometer

   The accelerometer measures force in the X, Y and Z direction. Its working is based on the principle of Newton's Second law of motion. It uses mass-spring system interconnected to parallel plate capacitor. The acceleration causes the displacement in the spring which affect the capacitance of capacitor. Hence, the acceleration can be measured as a change in capacitance. It can measure a range of ±2 g to ±16 g.
   It will measure the gravitational field strength and can also function as seismometer. Seismometer measures the different types of moonquakes and meteorite impacts. The magnitude of the moonquakes differentiates the cause of it. For example, deep moonquakes occurring 700 km beneath surface are tidal events by Earth on magma. It ranges from 1-5 MMS.

   $$MMS = log_{10}\left(\frac{A}{T}\right) + 5.5$$

   Where, MMS is Moonquake Magnitude Scale
   A is Max amplitude in micrometer
   T is time period of wave in second
   5.5 is calibration constant

2. Secondary Sensors

2.1 Capacitive sensor

The capacitive sensor determines the dielectric constant of the Lunar regolith that is in direct contact with the interdigitated* sensor. It consists of a series of thin line parallel plates which is exposed on backside of LunaSat. When it comes in contact with any material, the material fills the space between the plates and act as dielectric. Different materials have different dielectric constant. The charging and discharging time depends on the capacitance which again depends on dielectric constant. Hence, it measures the dielectric constant of materials in contact with it by measuring the charging and discharging time of the capacitor.

The capacitive sensor can perform following measurement on Lunar surface:

- Directly detects the dielectric constant of material being measured
- Indirectly measures composition makeup of Lunar regolith
- Indirectly measures moisture content of Lunar regolith

2.2 Thermopile

The thermopile measures temperature of objects in front of it by measuring the radiation released by the object. All matter with a temperature above absolute zero naturally emits electromagnetic radiation, or light, through a process called thermal radiation. Thermopiles remotely sense temperature by detecting and converting thermal radiation into an electrical signal which can be interpreted as a temperature. It will measure the temperature of the lunar surface. The record of temperature of days and nights can help us estimate the internal temperature of the moon.

2.3 Management Section

2.3.1 Methodology

The detailed methodology that shall be followed during the GLEE mission working on LunaSat is shown in figure.

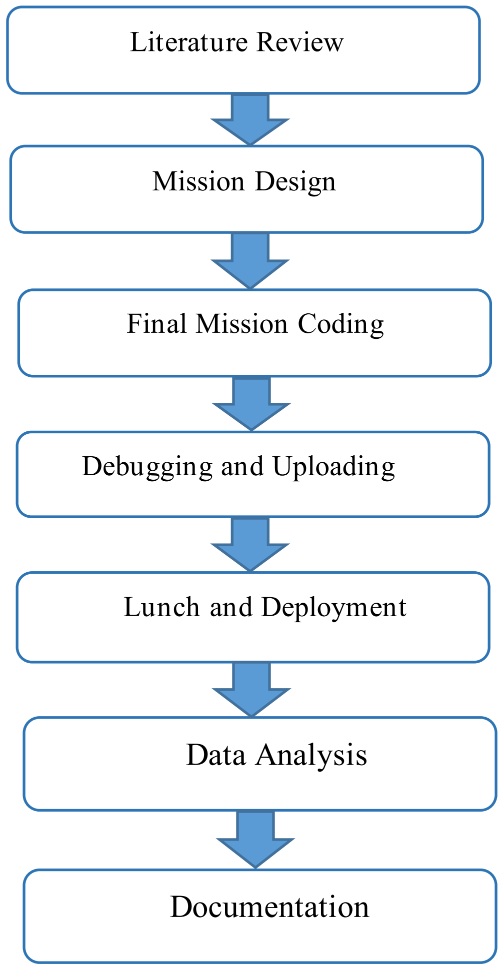

Fig: Methodological flowchart

2.3.2 Team Composition

S.N	Name	Designation	Status
1	Krishna Gupta	Team lead	B.E 2nd Year Mechanical Engineering
2	Manoj Bhatta	Team member	B.E 2nd Year Mechanical Engineering

3	Pranesh Pyara Shrestha	Team member	B.E 2nd Year Electronics and Communication Engineering
4	Dr. Khem Poudyal	Mentor	Professor, Applied Science

2.3.3 Work Schedule

The mission will be completed in 2 years as described in following table.

Activity	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Total months
Literature Review					3
Mission design					4
Final Mission Coding					5
Debugging and Uploading					2
Lunch and Deployment					3
Data Analysis					5
Documentation					2

2.4 Relevant Graphs/Sketches

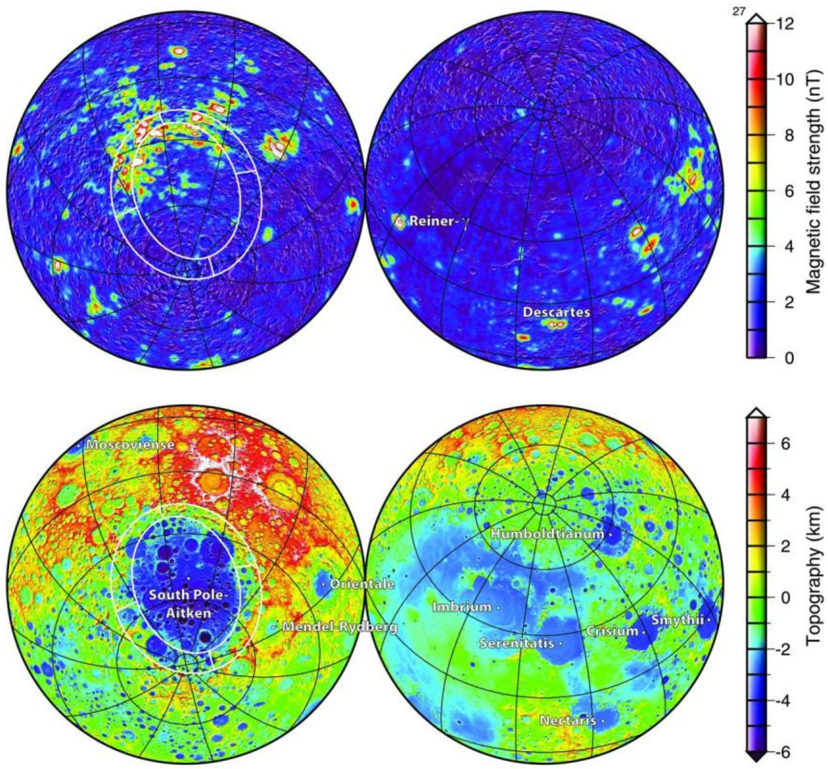

Fig: Map of magnetic field strength and topography of moon

The Moon has a localized magnetic field that varies in strength and orientation across its surface, and a highly varied topography that includes mountains, craters, and maria. The Moon's magnetic field is weaker than the Earth's, and is thought to be remnants of a magnetic field generated by dynamo processes in the Moon's molten core over 3 billion years ago. The Moon's topography is shaped by a range of processes, including impacts from meteoroids and asteroids, volcanic activity, and tectonic activity. The Moon's unique features make it a valuable laboratory for studying the history and composition of the Moon and the broader solar system.

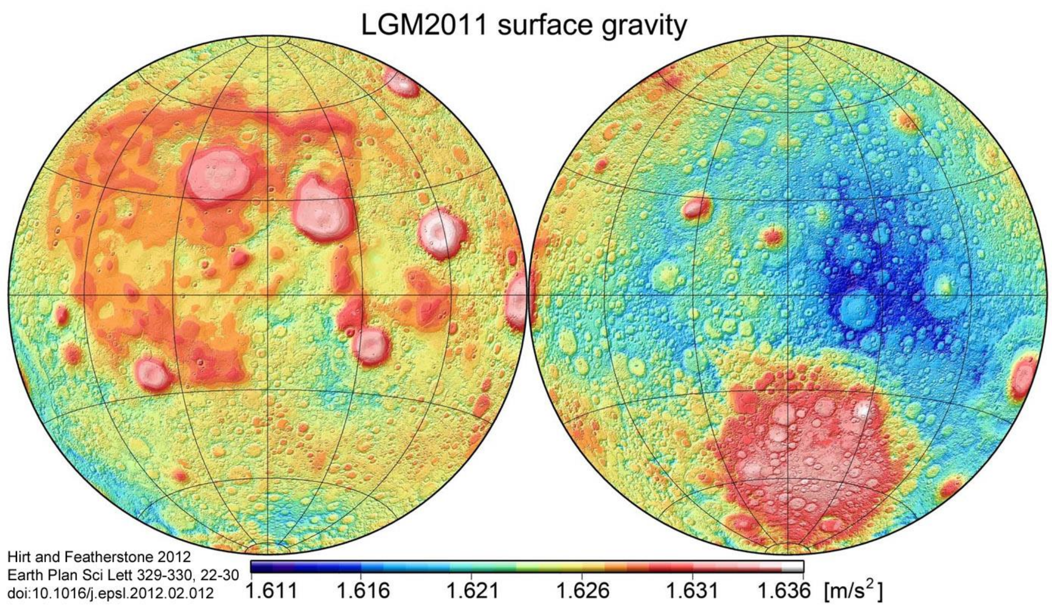

Fig: Gravity acceleration at the surface of the Moon in m/s^2. Near side on the left, far side on the right. Map from [Lunar Gravity Model 2011](#) [Archived](#) 2013-01-14 at the [Wayback Machine](#).

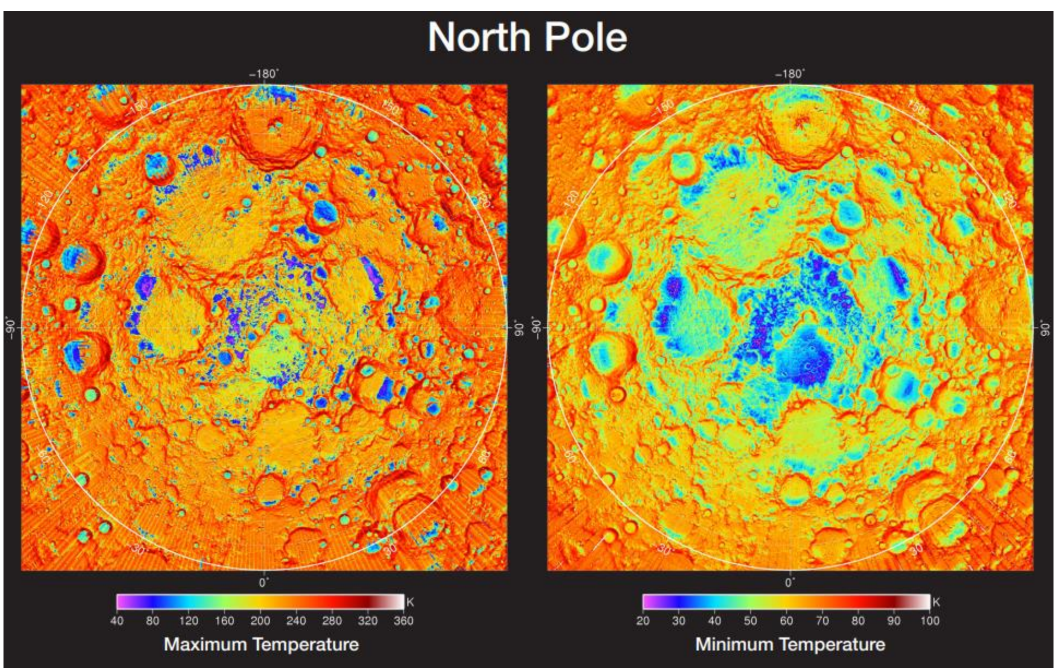

Fig: LUNAR RECONNAISSANCE ORBITER: Temperature Variation on the Moon

Daytime temperatures near the lunar equator reach a boiling 250 degrees Fahrenheit (120° C, 400 K), while nighttime temperatures get to a chilly -208 degrees Fahrenheit (-130° C, 140 K). The Moon's poles are even colder.

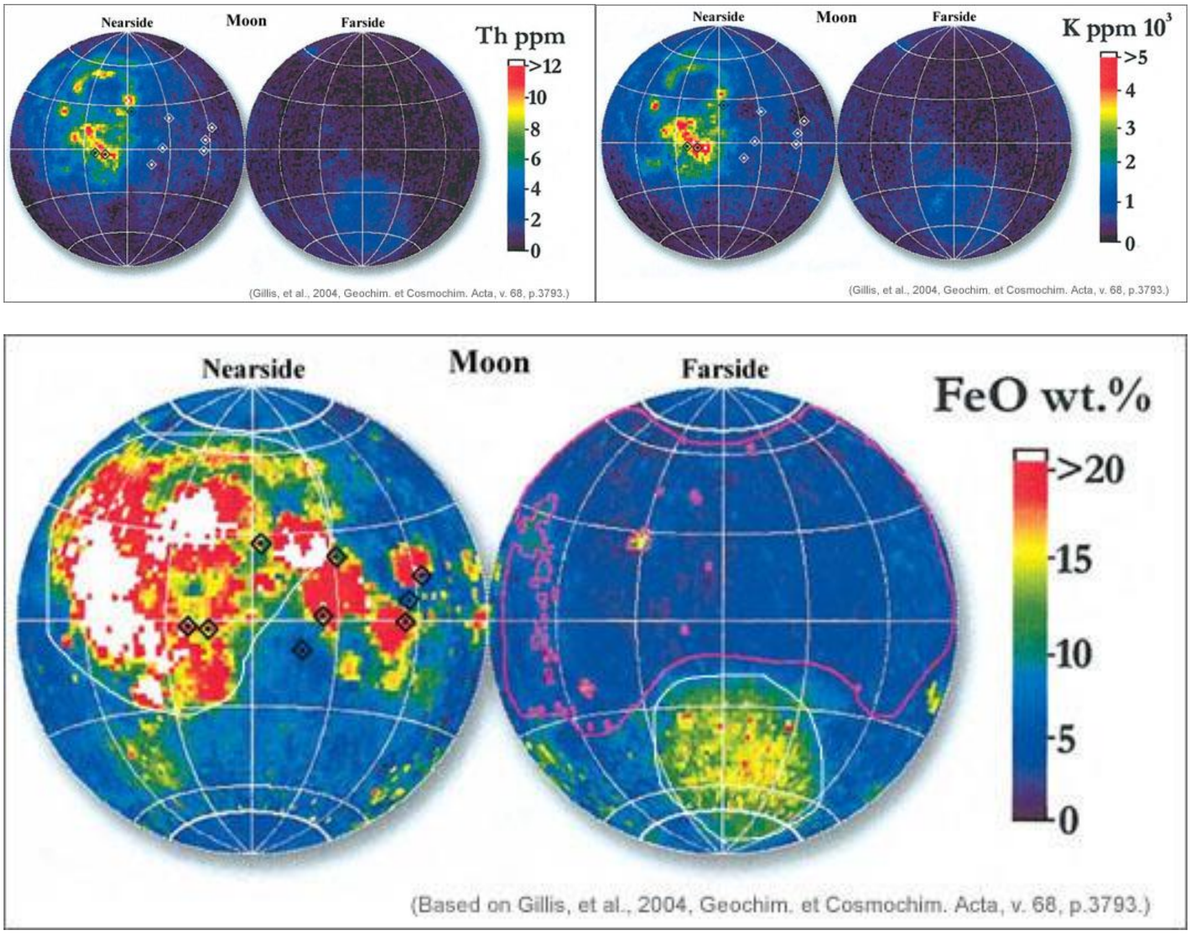

Fig: Composition map of the moon

3. Data Management

LunaSat sensor readings are recorded, processed then transmitted. Observation data is transmitted to the DM, processed then relayed through DM Lander interface, directly to Earth or to Earth via Satlink. Upon data relay to GLEE mission control, data is curated and entered into an accessible GLEE database.

4. References and citations

- *Hartmann, W. K., & Davis, D. R. (1975). Satellite-sized planetesimals and lunar origin. Icarus, 24(4), 504-515.*

- *Canup , R. M. (2004). Simulations of a late lunar-forming impact. Icarus, 168(2), 433-456.*

- *Benz, W., & Cameron, A. G. (1990). The origin of the Moon and the single-impact hypothesis III. Icarus, 87(2), 289-308.*

- *https://moon.nasa.gov/inside-and-out/overview/*
- *https://www.science.org/doi/10.1126/science.1214773*
- *https://en.wikipedia.org/wiki/Gravitation_of_the_Moon*
- *https://lunar.gsfc.nasa.gov/images/lithos/LROlitho7temperaturevariation27May2014.pdf*
- *http://www.psrd.hawaii.edu/Dec04/LunarCrust.html*

5. Current Support

This mission is currently supported by NASA's Artemis, Artemis Student Challenge, Colarado Space Grant Consortium (COSGC) and GLEE as a whole.

6. Proposal Budget, Budget narratives and Budget detail

S.N	Domain	Cost
1.	Prototype and Testing	$80
2.	Satellite Kits	$100
3.	Lunch and Deployment	$50000
4.	Ground control and Operation	$500
5.	Documentation and research	$500
Total		$51180