STELLAR PANORAMA

VOYAGE TO INFINITY

SAMAVESH

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2024

SPECIAL THANKS FOR THE GUIDANCE

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Electronic propulsion and implications

by Hiraish Kumar
(Department of Electrical Engineering)

Introduction:

To move forward we push things back, the rate at which we push them determines how fast we go .Classical chemical rockets use a oxidiser to explosively expand fuel at a rate enough to push their payload which is usually less than 10% of the weight of the rocket.It was this problem that led to the invention of one of its first alternatives the electrical propulsion system Instead of pushing lot of stuff very past for lot of force EP (Electric propulsion) pushes very little VERY fast for very long Instead of relying on the combustion of fuel to generate thrust, ion propulsion depends upon accelerating electrically charged particle to exponentially higher speed than the exhaust gas This innovative approach results in significantly higher exhaust velocities, enabling spacecraft equipped with ion propulsion to achieve greater speeds while consuming far less propellant.

Mathematical modeling of the Motion of a Rocket

Tsiolkovsky rocket equation

The classical rocket equation, or ideal rocket equation is a mathematical equation that describes the motion of vehicles that follow the basic principle of a rocket: a device that can apply acceleration to itself using thrust by expelling part of its mass with high velocity can thereby move due to the conservation of momentum. Δv = ve ln m0 mf (1) In this equation: where: Δv is the change in velocity ve is the effective exhaust velocity m0 is the initial mass of the rocket (including propellant) mf is the final mass of the rocket (after propellant has been expended

Electronic propulsion and implications

implications of this Equation

Here we see the graph of the Tsiolkovsky rocket equation plotted for the percentage of total mass ejected on the x-axis and the instantaneous change in velocity on the y axis . each of the plot lines plots for a different velocity of ejection of gas . Here we the primary conflict of rocket propulsion . Classical chemical rockets use a oxidiser to explosively expand fuel at a rate enough to push. By the

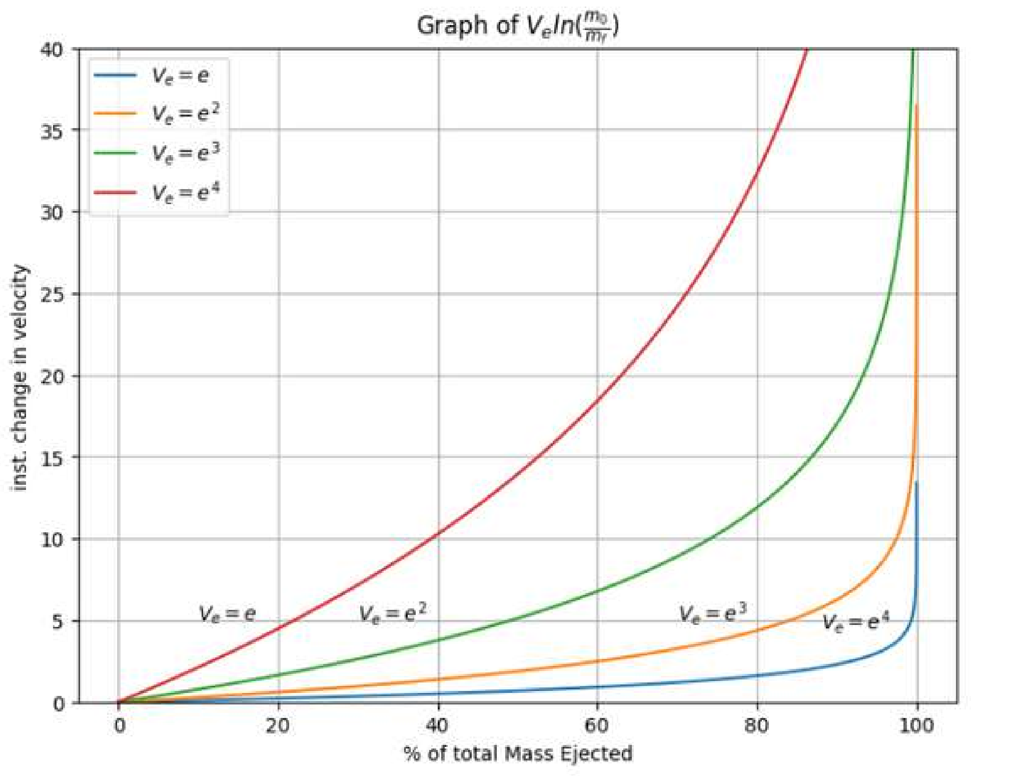

Figure 1: acceleration produced for % of total mass ejected

end of the 70s scientist had figured out a way to cheat the equation. Instead of increasing the rate at which mass was ejected. They could increase the speed at which it was ejected. Which instead reduced the mass ejection requirement

Electronic propulsion and implications

OVER PROCESSING AND SOURCE

voltage difference (Hall voltage) across an electrical conductor, transverse to an electric current in the conductor and a magnetic field perpendicular to the current. In the case of a Hall thruster, the conductor is the plasma, the electric current is generated by the ionized propellant, and the magnetic field is provided by magnets [CCJ+19] Electrons are produced by a hollow cathode (negative electrode) at the downstream end of the propulsion. The anode (positive electrode) or "channel" is charged to a high potential by the power supply of the thruster. The electrons are drawn to the walls of the channel and accelerate in the upstream direction. As the electrons migrate into the channel, they experience a magnetic field created by the thruster's strong electromagnets. This high-strength magnetic field traps the electrons, causing them to form a ring at the downstream end of the thruster tube. The Hall thruster is named for this wave of electrons, called the Hall Current. [Aks21] The propellant, consisting of an inert gas such as xenon or krypton at low pressure, is pumped into the thruster tube. Because Hall thrusters use inert gas for propellant, there is no chance of explosion as for chemical rockets. Any of the trapped electrons in the channel collide with the propeller atoms forming ions. As the propellant ions are created, they feel the electrical field formed between the (positive) channel and the (negative) electron ring and accelerate out of the thruster, forming an ion beam. The thrust is provided by the force given to the electron cloud by the ions. This force is applied to the magnetic field and, in turn, is sent to the magnetic circuit of the Thruster. The electrons are extremely mobile and drawn to the ions in the beam, allowing an equivalent number of electrons and ions to exit the propeller at the same time. This allows the thruster to remain electrically inert overall. [Aks21]

Electronic propulsion and implications

The Hall Type Electronic Propulsion Engine :

WORKING

The power supply is normally some source of electrical power such as solar or nuclear power. The solar electrical propulsion system (SEP) uses solar panels to produce electricity, and the nuclear elec trical propulsion system (NEP) uses a nuclear power source attached to an electrical generator. This production of electricity is due to the power source. They are circuit machines that transform the electrical input from the utility line to the required voltage and current to be used by the system in question. They have the same function as linear amplifiers, but they are much more effective because the use of linear amplifiers results in a lot of power loss due to the use of a capacitor to shift voltage and current. Another usage of the PPU is that the electrical power provided by the power source is transferred by the PPU by providing the necessary power to each part of the Hall Thruster [Aks21

POWER PROCESSING AND SOURCE

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Electronic propulsion and implications

FUTURE OF THE TECHNOLOGY

In 2010, ISRO used Hall effect ion propulsion thrusters in GSAT-4 . It had four Xenon powered thrusters . Two of them were Russian and the other two were Indian. The Indian thrusters were rated at 13mN. In 2013, ISRO funded development of another class of electric thruster called Magnetoplasmady namic Electric Propulsion Thruster. The project subsequently developed a technology demonstrator prototype Magneto Plasma Dynamic Thruster (MPD) using Argon propellant with a specific impulse of 2500s at a thrust of 25 mN. [Raj] India has increasingly started using electric propulsion technol ogy for its space missions. The Indian Space Research Organisation (ISRO) has integrated electric propulsion systems, including Hall-effect thrusters, into its spacecraft to enhance mission capabilities

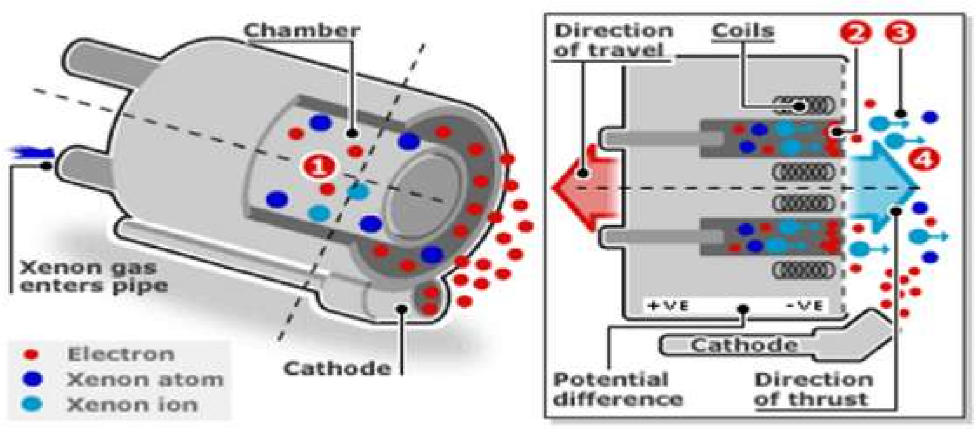

Figure 2: Working of the Hall Thruster

Electronic propulsion and implications

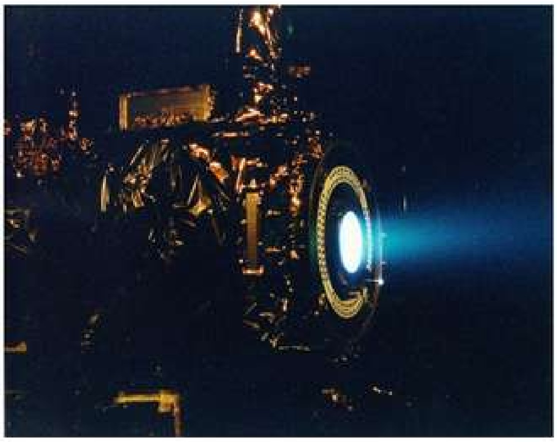

Figure 3: The 2.3kW NSTAR ion thruster developed by NASA for the DEEP SPACE 1

RELIABLE SPACE TRAVEL

In 2The ingenuity of this design is that this system can produce about 20x the specific impulse of the tradition Chemical rockets and they are capable of producing their own fuel. From fission that is used to power the space craft, the most common propellent used Xenon is freely liberated form the decay of iodine 135 as a product of nuclear fission. High-power ion propulsion system designed to reduce mission cost and trip time, operates at 3 times the power level of NSTAR(NASA solar technology application readiness) used in the Deep Space 1 and was tested continuously for 51,000 hours (equivalent to almost 6 years of operation) in ground tests without failure, to demonstrate that the thruster could operate for the required duration of a range of missions. [Den15]

Electronic propulsion and implications

IChina has begun construction on a new space station, and its core module features four ion thruster, which produce thrust using electricity instead of traditional rocket fuel. Gallimore's system X3 ion thruster producing 5.4 Newtons of thrust , more than any other ion engine.[Jon21] The inclusion of an ion propulsion system in a long-running, Earth-orbiting space station will give researchers a chance to test out the tech while astronauts are still close to home , and if it works as hoped, it could one day ferry explorers to Mars and even more distant destinations.

TECHNOLOGICAL LIMITATIONS

The greatest inhibitor to this technology right is not the amount, but the sheer density of energy required to keep this system running. Most modern satellite that use this system can only produce few Newton of force due to only relying on solar arrays as a source of energy An immediate remedy to this problem would be using nuclear fission reactors on board Despite the thrust being produced in the order of 1-0.1 newtons, electric propulsion systems can keep running for months on end (due to self refuelling)without the need for refuelling making them excellent candidates for deep space exploration. Like the Deep Space 1 [Hal

CONCLUSION

Hall Thruster has proved to be a feasible and efficient alternative to traditional debugging systems. With very low fuel demand due to the very high specific current generation, Hall Thruster can cope comfortably with chemical systems even though the power production is very low. The system can be used for various mechanical criteria, such as orbit station orbit for geostationary satellite orbit, location monitoring and multi-purpose missions. While chemical resistance is not very suitable for the deep space deployment of Hall Thruster, it is also accessible at high speeds.

Electronic propulsion and implications

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XPoSat

Study of X-ray polarisation and cosmic sources

by Pujarani Sahoo
(Department of Electrical Engineering)

Introduction:

The Indian Space Research Organisation(ISRO) welcomed the new year with the launch of its X-Ray Polarimeter Satellite(XPoSat): making India, second nation in the world to launch an advanced astronomy observatory to study X-Ray polarisation and its cosmic sources,
like Black Holes, Neutron stars and Magnetars.

ISRO's PSLV-C58 has launched XPoSat satellite into an Eastward low inclination orbit on January 01, 2024 9:10 Hrs IST, from the Satish Dhawan Space Centre in Sriharikota in Andhra Pradesh .After injection of XPoSat, the PS4 stage will be restarted twice to reduce the orbit into 350km circular orbit to maintain in 3-axis stabilized mode for orbital platform(OP) experiments.
The Configuration of the mainframe systems are derived based on the heritage of IRS satellites. It carries two payloads namely POLIX (Polarimeter Instrument in X-rays) and XSPECT (X-ray Spectroscopy and Timing). POLIX is realized by Raman Research Institute and XSPECT is by Space Astronomy Group of URSC.

XPoSat

Study of X-ray polarisation and cosmic sources

POLIX

POLIX is an X-ray Polarimeter for astronomical observations in the energy band of 8-30 KeV. It will observe about 50 bright astronomical sources during the planned lifetime of XPoSat mission, i.e. 5 years, which will help the astronomers to understand the orientation and strength of magnetic fields in celestial objects.

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The instrument is made up of a collimator, a scatterer and four X-ray proportional counter detectors that surrounds the scatterer. The scatterer is made up of low atomic mass material which causes anisotropic Thomson scattering of incoming polarised X-rays. The collimator restricts the field of view to 3 degree x 3 degree so as to have only one bright source in the field of view for most observations.
This in turn, provides crucial insights into the nature and behaviour of Pulsars, regions around Black holes and other cosmic phenomena emitting X-Rays.

XSPECT

XSPECT is an X-ray Spectroscopy and Timing payload onboard XPoSat, which can provide fast timing and good spectroscopic resolution in soft X-rays.
XSPECT payload is developed by the Space Astronomy Group of U R Rao Satellite Centre (URSC)/ISRO, Bengaluru. It can provide long-term monitoring of spectral state changes in continuum emission, changes in their line flux and profile, simultaneous long term temporal monitoring of soft X-ray emission in the X-ray energy range 0.8-15 KeV.

XPoSat

Study of X-ray polarisation and cosmic sources

An array of Swept Charge Devices (SCDs) provide an effective area >30 cm2 at 6 KeV with energy resolution better than 200 eV at 6 KeV. Passive collimators are used to reduce the background by narrowing the field of view of XSPECT.

During its performance verification phase, XSPECT was directed towards Cassiopeia A, a standard celestial source used for instrument evaluation. The observation commenced on January 5, 2024, capturing the supernova remnant's emission lines corresponding to elements such as Magnesium, Silicon, Sulphur, Argon, Calcium, and Iron.

Scientific goals of this mission:-

- To study the distribution of magnetic field, geometric anisotropies, alignment w.r.t line of sight, nature of accelerator in galactic cosmic X-Ray sources by measuring degree of polarization and its angle.
- Structure and geometry of magnetic field of neutron stars, mechanism of X-Ray beaming and its relation with luminosity and mass of accretion rate of powered pulsars.
- Detailed understanding of galactic black hole by binary sources.
- To study and confirm about production of X-Rays is either from polar cap of neutron star or outer cap of pulsar magnetosphere.
- To distinguish the synchrotron mechanism as dominant over thermal emission in Supernova remnants.

XPoSat

Study of X-ray polarisation and cosmic sources

Recent Observations:-

A pulse profile of the Crab pulsar is generated from the observations carried out by POLIX during January 15-18, 2024. The Crab pulsar, a pulsating star, resides near the centre of the Crab Nebula and spins about its axis approximately 30 times per second. The POLIX payload was activated in two stagesand initial scan observations were conducted around the Crab pulsar, the intended first target. The data plotted was collected during January 15-18, 2024, and thoroughly reviewed for confirmation. The data aligns with expectations. As the sole payload offering data in this energy band, POLIX is poised to offer unique insights and contribute to understanding the physical processes associated with Astronomical X-ray sources.

XPoSat is one of its kind as it has advanced technology within limited supplies and budget. It has proved itself as the best polarimetry satellite till date. Furthermore, our scientists are working their level best towards this mission.

IEEE VSSUT STUDENT BRANCH

got approval for

WOMENS IN ENGINEERING AFFINITY GROUP

We are thrilled to announce that the IEEE VSSUT Student Branch is taking a monumental step forward by opening a new WIE_(Women in Engineering)_ Affinity Group, reinforcing our commitment to women empowerment in the fields of technology!

As a chapter dedicated to fostering innovation and inclusivity, we couldn't be prouder to expand our reach and support network to empower women in the field of engineering. By launching this new initiative, we aim to provide a platform for female engineers to connect, collaborate, and thrive in their academic and professional pursuits. In a world where diversity and representation are increasingly recognized as crucial components of progress, our focus on women empowerment in technology underscores our dedication to creating an environment where all individuals, regardless of gender, can excel and contribute meaningfully.

Join us in celebrating this milestone, and stay tuned for exciting updates as we embark on this empowering journey together!

Odysseus

Entry to an Era of Commercial Explorations

Introduction:

In February 2024, humanity took a giant leap back onto the lunar surface. The IM-1 mission, a collaborative effort between NASA's CLPS (Commercial Lunar Payload Services) program and Intuitive Machines (IM) successfully landed Odysseus, or Nova-C, the first spacecraft on the Moon's South Pole region, marking the United States' first return since Apollo 17 in 1972 and the first private lunar lander to send vital research data from each NASA payload from the lunar surface. It is also the first successful commercial lunar lander to softly touch down on the Moon.

Objective:

The Odysseus mission, a pioneering endeavor in space exploration, had two primary objectives. Firstly, it aimed to achieve a historic feat by landing a privately-built spacecraft on the Moon for the first time. This groundbreaking accomplishment not only highlighted the capabilities of commercial spacecraft but also rekindled American aspirations for lunar exploration

Secondly, the mission was dedicated to scientific exploration. It delivered a range of payloads to a previously unexplored region near the Moon's South Pole: specifically, the "Malapert A" crater. This location is hypothesized to harbor potential reserves of water ice. The payloads conducted experiments to meticulously study the lunar environment and gather invaluable scientific data, expanding our understanding of the Moon and its resources.

RFMG:

A Radio Frequency Mass Gauge (RFMG) on board estimated the amount of propellant that was available during the IM-1 mission. This was the first long-duration test of an RFMG on a standalone spacecraft.

Odysseus

Entry to an Era of Commercial Explorations

Mission Launch:

The Odysseus Lander, embarked on its mission from NASA's Kennedy Space Center in Florida. Launched by SpaceX on February 15, it soared into Earth's orbit atop a Falcon 9 rocket launcher. This remarkable feat propelled the lander to astounding speeds, surpassing 40,000 kilometers per hour, as it journeyed towards the Moon. It successfully placed it on translunar trajectory towards the Moon. The event was broadcasted live, captivating space enthusiasts and the general public alike, as they witnessed the beginning of a new chapter in lunar exploration.

Odysseus lander arrived at the "Malapert-A" crater and was meant to operate for approximately a week before the Sun sets at the site, leading to a temporary inactive period. The lander also holds the distinction of being the first liquid methane and liquid oxygen (Methalox) powered spacecraft to fire beyond low-earth orbit and the first Methalox spacecraft to successfully land on an off-world celestial body. The Odysseus lander carried six payloads developed by NASA, in addition to others from commercial and educational institutions.

SATELLITE LANDING:

In 2020, potential landing sites were identified between the Sea of Serenity (Mare Serenitatis) and the Sea of Crises (Mare Crisium). Lunar Maria, large plains formed by lava, guided the selection. Later, a highlands location near the Moon's south pole was chosen for its possible water source for a future lunar base. The Malapert-A crater area, 300 km from the pole, was selected for its safety and flatness.

Odysseus executed its lunar orbit insertion (LOI) on February 21, altering its velocity by 800 m/s (1,800 mph). IM reported the 408-second main engine LOI burn, placed the lander in a 92 km (57 mile) lunar orbit. On February 22 IM acknowledged a subsequent "lunar correction maneuver" that had further raised the orbit. During its 24-hour lunar orbit, Odysseus transmitted high-resolution images of the Moon's surface. IM fine-tuned the descent burn parameters based on data gathered from the lunar orbit insertion burn.

Odysseus

Entry to an Era of Commercial Explorations

Achivement:

Odie's final descent began at 23:11 UTC on February 22. It landed in a 1 km diameter crater on a slope of about 12 degrees, at 80.13o S, 1.44o E at Malapert A, roughly 1.5 km from the planned landing position: an area with water ice. Controllers received faint communication signals. Initially, it seemed the lander was vertically oriented, but later it was determined that Odie had tipped over, at a 30-degree angle to the horizontal. This affected the radio transmission rates but did not hinder solar panels and scientific instruments. Some of the landing gears broke upon impact. The lander might have lost one or more landing struts and rested on an oxygen tank. Odysseus marked the first American moon landing since Apollo 17 in 1972 and the first American moon landing since Apollo 17 in 1972 and the first commercial lunar lander.

FAILURES:

Odysseus was not a perfect mission, but it did its job. IM said that the team was able to activate all of its payloads and collect data from each of them except from the students' deployable camera that was built to capture the final moments of touching down. Although, a total of 350 MB data returned to Earth, in terms of space, this is still much lower or nowhere near the expected outcome.

The official IM-1 mission ended on February 29th, as Odie was not designed to survive the Moon's harsh temperatures without sunlight. Odysseus lasted longer than the company anticipated after it ended up on its side with crippled solar power and communication. Flight controllers received a final photo and instructed the systems to standby, allowing a potential wake-up in two to three weeks, on surviving the harsh lunar nights. Intuitive Machines' spokesperson, Josh Marshall, mentioned that these actions led to the lander's battery depletion and entering a long sleep. The lander's groundbreaking voyage and the wealth of knowledge delivered from the lunar surface.

"Good night, Odie. We hope to hear from you again," the company said via X.

Before losing power, Odysseus sent back what Intuitive Machines called "a fitting farewell transmission."

CONCLUSION:

As of March 2024, Intuitive Machines has expressed the possibility of additional data collection by the Odysseus lander during future lunar days. Attempts would be made to restart the spacecraft in about 3 weeks time at local noon when there is sunlight on the solar panels again.

The 21st century has witnessed remarkable advancements in space history, as Rocket Lab pioneers small rockets, SpaceX revolutionizes reusable large rockets, and Intuitive Machines achieves a successful lunar landing, overcoming obstacles. This inspiring tale showcases resilience, hard work, and perseverance, all rooted in meticulous planning, development, and execution.

SOCIAL INNOVATION USING SUSTAINABLE TECHNOLOGY

IEEEVSSUT THE IEEE VSSUT STUDENT BRANCH SUCCESSFULLY HOSTED THE PRELIMINARY ROUND OF THE INTERNATIONAL HACKATHON LEEE YESIST12, A DYNAMIC PLATFORM DEDICATED TO FOSTERING INNOVATION AND SUSTAINABILITY AMONG YOUNG VISIONARIES. THE EVENT WAS GRACED BY THE DISTINGUISHED VICE CHANCELLOR OF VSSUT, BURLA, PROF. DR. BANSIDHAR MAJHI AND THE JURY PANEL INCLUDING PROF. HARISH KUMAR SAHOO, BRANCH COUNSELOR OF IEEE VSSUT STUDENT BRANCH AND THE HEAD OF DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING, VSSUT BURLA, DR.
RASESWARI PRADHAN, ASSISTANT PROFESSOR AT THE
DEPARTMENT OF ELECTRICAL ENGINEERING, VSSUT BURLA, AND MR. DHEERAJ AGRAWAL, DEPUTY GENERAL MANAGER AT TPWODL, ODISHA. THEIR COLLECTIVE EXPERTISE SERVED AS A BEACON OF GUIDANCE FOR PARTICIPANTS, OFFERING VALUABLE FEEDBACK AIMED AT REFINING AND ENHANCING THE QUALITY OF PROJECTS PRESENTED.

INSAT-3DS

INDIA'S NEW WEATHER SATELLITE

by Namrata Mohanto

(Department of Metallurgical and Materials Engineering)

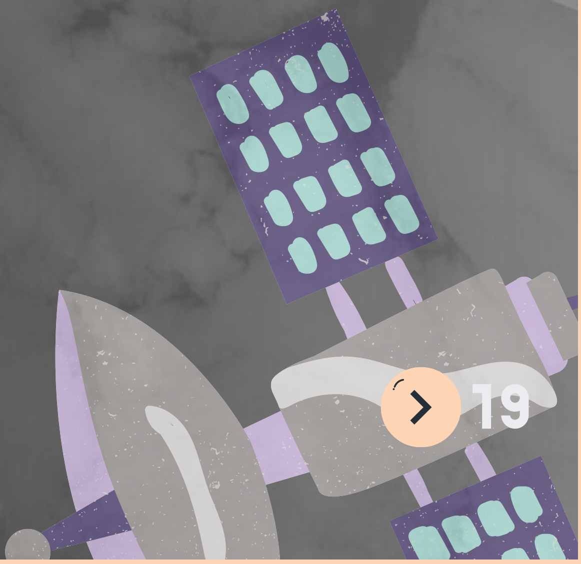
INTRODUCTION:

The GSLV-F14 in its 16th mission aims at deploying the INSAT-3DS meteorological satellite into the geosynchronous transfer orbit (GTO). The GSLV-F14 lift off at 5:35 pm Saturday from the Satish Dhawan Space Center Sriharikota . This crucial mission was carried out by the rocket which was named as "naughty boy" by the former chairman of the Indian space research organization since the rocket has not performed adequately in 6 of its 15 flights ,it has a failure rate of 40%.This mission is designed to operate in space for 10 years .It aims to boost India's environment monitoring, oceanic observations, weather forecasting and disaster relief operations.

GSLV-F14:

GSLV is a three stage ,51.7 m long launch vehicle having a lift of mass of 420 tons .The first stage (GS1) comprises a solid propellant and four earth -storable propellant stages(L-40) which carry 40 tons of liquid propellant in each.

The second stage (GS2) is also an earth -storable propellant stage loaded with 40 tons propellant .The third stage (GS3) is a cryogenic stage with a 15 -tons propellant including liquid oxygen(LOX) and liquid hydrogen(LH2) GSLV can be used to launch a variety of spacecraft which is capable of performing communications , navigations ,earth resource surveys , and any other exclusive mission .



INSAT-3DS

INDIA'S NEW WEATHER SATELLITE

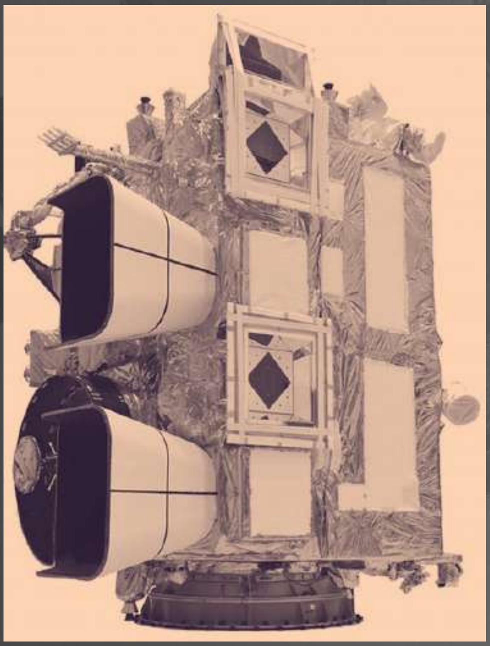
INSAT-3DS:

This satellite is on a mission of third generation meteorological satellite from geostationary orbit. This mission is fully funded by the Ministry of Earth Science (MoES). It is designed for enhanced meteorological services and monitoring of land and ocean surfaces for weather forecasting and disaster warning. The satellite will be more useful for the meteorological services along with the presently operational satellite INSAT-3D AND INSAT-3DR.

ISRO's platform is equipped with an imager payload with a six-channel optical radiometer to generate images of the earth and its environment, a 19-channel sounder payload to provide information on the atmosphere, communication payloads including a data relay transponder to receive meteorological, hydrological and oceanographic data from automatic data collection platforms.

OBJECTIVE:

The primary objective of the mission includes, monitoring earth's surface, carry out oceanic observations and its environment. To provide the vertical profile of various meteorological parameters of the atmosphere. To provide the data collection and dissemination capabilities from the Data Collection Platforms (DCPs). To provide satellite aided search and rescue services. So, this mission will boost India's weather, climate and ocean related observations and services, expanding knowledge and better disaster management and preparedness in the future.



WE ARE THRILLED TO ANNOUNCE THE APPROVAL OF THE IEEE COMMUNICATIONS SOCIETY(COMSOC) CHAPTER UNDER THE IEEE VSSUT STUDENT BRANCH . THIS MARKS A SIGNIFICANT MILESTONE IN OUR JOURNEY TOWARDS FOSTERING A CULTURE OF INNOVATION AND TECHNICAL EXCELLENCE WITHIN OUR CAMPUS.

IEEE ComSoc
IEEE Communications Society
VSSUT STUDENT BRANCH CHAPTER

SCAN THIS QR CODE TO ATTMPT THE QUIZ , TOP PERFORMERS WILL BE FEATURED IN OUR NEXT MAGAZINE ,

Smart Lander

For Investigating Moon

by Bhavitabya Dhal
(Department of Electronics and Telecommunication Engineering)

Introduction:

One of the key challenges in lunar exploration is a harsh and unpredictable lunar environment, which includes rugged terrain and low gravity. To overcome these challenges, the smart lander system is equipped with advanced obstacle avoidance algorithms and landing gear that can adapt to varying surface conditions. Additionally, the system is designed to withstand the extreme temperatures and radiation levels found on the moon, ensuring its durability and reliability during long-duration missions. The smart lander system is not only a technological achievement but also a significant step forward in our quest to explore and understand the moon. Its ability to autonomously navigate and conduct scientific investigations has the potential to revolutionize lunar exploration, paving the way for future missions that could uncover discoveries and expand our understanding of the solar system.

Main Objective for Smart Lander for Investigating the Moon:

The main objective of a smart lander for investigating the moon is to conduct comprehensive scientific investigations of the lunar surface and environment. This includes studying the moon's geology, mineral composition, and physical properties to enhance our understanding of its formation and evolution. Additionally, the smart lander aims to Gather data on the moon's magnetic field, radiation levels, and seismic activity to help scientists better understand the moon's internal structure and geophysical processes.

Another key objective is to search for signs of past or present life on the moon, including microbial life or organic compounds. This could provide valuable insights into the potential for life beyond Earth and the conditions necessary for its existence. Furthermore, the smart lander seeks to identify potential resources on the moon, such as water ice or minerals, that could be used to support future human exploration missions.

By characterizing the moon's resources, the smart lander can help inform future mission planning and resource utilization strategies. Overall, the main objective of a smart lander for investigating the moon is to advance our scientific understanding of Earth's nearest celestial neighbour and pave the way for future exploration and potential habitation.

Challenges for Smart Lander for Investigating the Moon:

Autonomous Navigation:

One of the primary challenges for a smart lander on the moon is autonomous navigation.
The lander must be able to navigate the lunar surface safely, avoiding obstacles and selecting optimal paths for exploration.
This requires advanced sensing and perception capabilities, as well as robust decision-making algorithms to ensure safe and efficient navigation.

Landing Accuracy:

Landing on the moon requires a high degree of accuracy to ensure the lander reaches its intended target location. Factors such as terrain variability, gravitational anomalies, and communication delays pose challenges to achieving a precise landing. Developing a propulsion system and guidance system capable of achieving this level of accuracy is a significant challenge for smart lander missions.

Harsh Lunar Environment:

The lunar environment is harsh and unforgiving, with extreme temperatures, vacuum conditions, and high levels of radiation. Designing a smart lander that can withstand these conditions for extended periods is a major challenge. Additionally, the lander must be able to operate effectively in low-gravity conditions, which can affect its mobility and stability.

Communication Delays:

Communication with a smart lander on the moon poses significant challenges due to the distance between Earth and the moon, resulting in communication delays of several seconds. This delay can impact the real-time control and operation of the lander, requiring the development of robust communication protocols and autonomous control systems.

Resource Limitations:

The resources available for a smart lander on the moon are limited, including power, data storage, and communication bandwidth. Designing a lander that can effectively manage and optimize these resources is a challenge, requiring efficient power management, data compression, and prioritization algorithms.

Dust and Regolith:

The lunar surface is covered in a layer of fine dust and regolith, which can pose challenges to the operation of a smart lander. Dust can accumulate on solar panels, reducing their efficiency, and interfering with sensors and other equipment. Developing mechanisms to mitigate the effects of dust and regolith is a challenge for lunar exploration missions.

Long-Distance Travel:

Traveling to the moon requires a long journey through space, which poses challenges in terms of propulsion, navigation, and communication. Developing a smart lander capable of surviving the rigorous of space travel and arriving safely on the moon is a significant challenge for mission planners and engineers.

Scientific Objective:

Meeting the scientific objectives of a lunar exploration mission poses challenges in terms of instrument selection, data collection, and analysis. Designing a smart lander that can effectively carry out the required scientific investigations and transmit the data back to Earth is a complex task that requires careful planning and execution. Overcoming these challenges will require collaboration between engineers, scientists, and mission planners to develop innovative solutions and technologies that enable successful smart lander missions to the moon.

Main Working Principle for Smart Lander for Investigating the Moon:

The main working principle of a smart lander for investigating the moon revolves around autonomous navigation, scientific data collection, and communication with Earth. The lander is designed to navigate the lunar surface safely, avoiding obstacles and selecting optimal paths for exploration using on-board sensors and AI algorithms. Upon landing, the lander deploys its scientific instruments to collect data on the moon's geology, mineral composition, and physical properties. These instruments may include cameras, spectrometers, and seismometers, among others, to capture detailed images and measurements of the lunar surface and environment.

Smart Lander

For Investigating Moon

The lander then processes the collected data onboard, using AI algorithms to analyze and prioritize the most relevant information for transmission back to Earth. This data is transmitted via a communication system, which may include direct communication with Earth or relay through an orbiting satellite, to provide scientists with real-time updates and insights into the lunar environment. Throughout its mission, the smart lander operates autonomously, making decisions based on pre-programmed instructions and real-time data to maximize the efficiency and effectiveness of its exploration activities. By combining advanced sensors, AI algorithms, and communication technologies, the smart lander enables comprehensive scientific investigations of the moon's surface and environment, advancing our understanding of Earth's nearest celestial neighbor. It is shown in figure 1.

Figure 1: A Half scale model of SLIM in landing configuration

Table 1: important parameters for smart lander for investigating moon

Name	Description
SLIM	Smart lander for Investigating Moon
Mission type	Lunar lander and lunar rover
Mission	6 months, 10 days
Spacecraft properties	
Manufacturer	Mitsubishi Electric
Launch mass	590 kg
Dry mass	120 kg
Dimensions	1.5 × 1.5 × 2 m

Start of mission	
Launch date	6 September 2023 23:42:11
Rocket	H-IIA 202
Launch site	Tanegashima Space Center
Lunar orbiter	
Orbital insertion	25 December 2023 07:51
Lunar lander	
Landing date	19 January 2024 15:20:00
Landing site	Shioli crater

Smart Lander

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Advantages of Smart Lander for Investigating Moon:

Autonomous Operation: Smart landers can operate autonomously, reducing the need for constant human intervention and enabling long-duration missions without direct human oversight.

Efficient Exploration: Smart landers can navigate the lunar surface more efficiently than human-operated vehicles, allowing them to cover more ground and gather more data in a shorter amount of time.

Real-time Decision Making: Smart landers can make real-time decisions based on sensor data and pre-programmed algorithms, allowing them to adapt to changing conditions and prioritize scientific objectives.

Data Collection: Smart landers are equipped with a variety of sensors and instruments for collecting data on the lunar surface and environment, providing valuable insights into the moon's geology, composition, and physical properties.

Remote Operation: Smart landers can be operated remotely from Earth, reducing the risk to human operators and enabling exploration in hazardous or difficult-to-reach areas of the moon.

Cost-effective: Smart landers are typically more cost-effective than manned missions, making them a cost-effective option for conducting scientific investigations on the moon.

Continuous Monitoring: Smart landers can continuously monitor the lunar environment, providing valuable data on long-term trends and changes over time.

Technological Development: Smart lander missions drive technological development in areas such as robotics, artificial intelligence, and communication systems, which can have applications beyond lunar exploration

Drawbacks of Smart Lander for Investigating Moon:

Limited Mobility: Smart landers typically have limited mobility compared to rovers, which can restrict their ability to explore large areas or navigate challenging terrain.

Limited Payload Capacity: Smart landers have limited payload capacity, which can restrict the number and types of scientific instruments that can be carried, potentially limiting the scope of scientific investigations.

Communication Delays: Smart landers on the moon experience communication delays with Earth due to the distance between the two bodies, which can impact the real-time control and operation of the lander.

Reliance on Solar Power: Smart landers often rely on solar power for their energy needs, which can be challenging in areas of the moon that experience long periods of darkness, such as polar regions.

Limited Lifespan: Smart landers have a limited lifespan due to factors such as wear and tear, exposure to harsh lunar conditions, and the finite supply of onboard resources such as fuel and power.

Risk of Mission Failure: Smart landers are complex systems that can be prone to mechanical or software failures, which can result in the loss of the lander and its scientific data.

Limited Scientific Output: Due to their limited mobility and payload capacity, smart landers may not be able to gather as much scientific data or conduct as diverse range of experiments as rovers or manned missions.

High Development Cost: Developing and deploying a smart lander mission to the moon can be expensive, requiring significant investment in technology development, testing, and mission planning.

Conclusion:

In conclusion, smart landers represent a promising avenue for advancing our understanding of the moon through autonomous exploration and scientific investigation. Despite some drawbacks such as limited mobility and payload capacity, smart landers offer numerous advantages, including efficient exploration, real-time decision-making, and cost-effectiveness. By leveraging advanced sensors, AI algorithms, and communication technologies, smart landers enable comprehensive scientific investigations of the lunar surface and environment, providing valuable insights into the moon's geology, composition, and potential resources. As we continue to develop and refine smart lander technologies, they will play an increasingly important role in lunar exploration, paving the way for future manned missions and potential habitation of Earth's nearest celestial neighbour.

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