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Student-Led Satellite Initiatives in India – A Comprehensive Review

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Abstract: Since its establishment, the Indian Space Research Organisation (ISRO) has deployed over a hundred satellites for diverse purposes, including communication, Earth observation, astronomy, navigation, lunar exploration, and interplanetary missions. Beyond its core programs, ISRO has actively encouraged Indian students to develop satellites by offering guidance, testing facilities for subsystems, and launch opportunities via the Polar Satellite Launch Vehicle (PSLV). These projects equip university students with hands-on experience in designing, fabricating, assembling, and testing electrical and mechanical systems, alongside exposure to project management, budgeting, scheduling, and mission operations. To date, Indian students have successfully launched nine satellites, with several others in development. Inspired by these efforts, numerous universities/colleges have tested their satellite prototypes using high-altitude balloons, while some have collaborated with international space agencies for launches. This paper highlights the key features and technologies employed in Indian student satellites.

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1. Introduction

An artificial satellite is a complex system orbiting Earth to fulfil specific objectives. It comprises two primary functional components: the payload and the bus (main frame). Payloads are mission-specific instruments or sensors. Remote sensing satellites typically carry imaging systems such as cameras, synthetic aperture radars (SAR), or scatterometers, while communication satellites are equipped with transmitters and receivers. Scientific satellites may house specialized instruments like gamma-ray detectors, X-ray monitors, or ultraviolet sensors to measure electron density and other space phenomena. The bus, or main frame, supports the payload and consists of interconnected electrical and mechanical subsystems. The electrical subsystems include the power system, communication system, data handling system, and attitude and orbit control system. The power system harnesses solar energy during sunlit phases, stores it in batteries for use during eclipses, and distributes power across all subsystems. The communication system receives commands from ground stations and transmits telemetry data, including temperature, pressure, power consumption, and satellite attitude and orbit information. Additionally, it relays high-volume payload data to Earth. The data handling system collects telemetry from various subsystems, formats it, and forwards it to the communication system. It also processes ground commands and manages payload data by compressing and encoding it before transmission. The attitude and orbit control system employs sensors and actuators to monitor and adjust the satellite's orientation and trajectory as needed. The mechanical subsystems encompass the structure, thermal control system, and deployment mechanisms. The structure, typically constructed from aluminium alloys or carbon fiber-reinforced plastic (CFRP), serves as the satellite's framework, housing all electrical and mechanical components while ensuring structural integrity and payload alignment. The thermal control system maintains optimal operating temperatures for onboard equipment. Deployment mechanisms are critical for components like solar panels and antennas, which are folded during launch to fit within the rocket's fairing and deployed once in orbit. Propulsion systems, often using chemical propulsion for their high thrust and simplicity, facilitate orbit adjustments and attitude corrections. The seamless integration of these

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systems enables the satellite to achieve its mission goals. Embedded software plays a vital role in data handling and attitude control, while ground-based systems rely on computing infrastructure and tracking antennas for satellite operations and data processing.

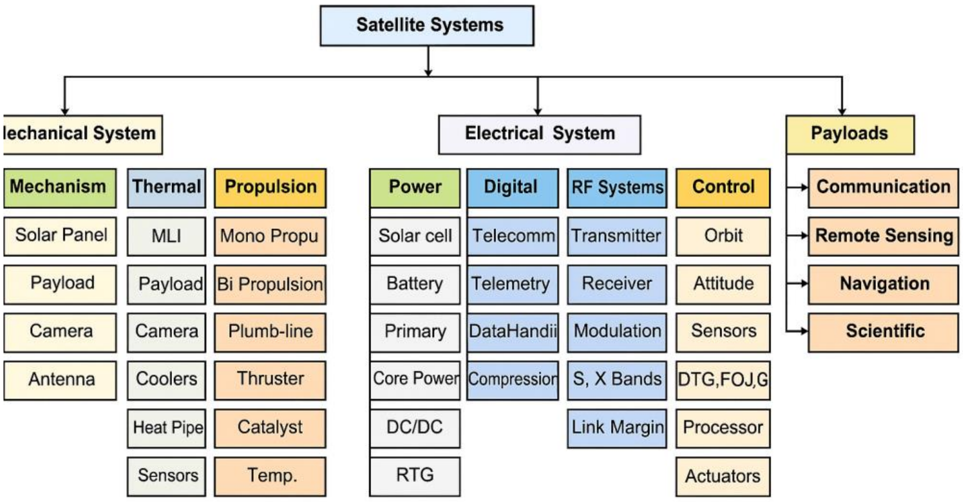

Fig. 1 Subsystems of satellite

Satellite projects demand multidisciplinary collaboration, offering students practical experience across engineering disciplines. Since student satellites are typically launched as secondary payloads alongside primary missions, they must adhere to stringent mass and size constraints. Consequently, these satellites are often classified as mini, nano, pico, or micro satellites, each tailored to specific applications. These satellites are designed, fabricated, and assembled at academic institutions using institutional funding. ISRO supports these efforts by providing access to advanced testing facilities, such as thermo-vacuum chambers and vibration tables at the UR Rao Satellite Centre, which would otherwise be prohibitively expensive. Furthermore, ISRO offers free launch services via the PSLV, significantly reducing barriers to entry for student-led projects. Figure 1 illustrates the key subsystems of a typical satellite, while Table 1 lists Indian student satellites and their affiliated institutions.

- MLI – Multi-Layer Insulation
- OSR- Optical Solar Reflector
- DC/DC – Power Converter
- DTG – Dynamically Tuned Gyro
- FOG – Fiber optic Gyro
- ES – Earth Sensor
- SS- Sun Sensor
- MT- Magnetic torquer
- RW- Reaction Wheel
- TH- Thrusters
- RTG- Radioactive Thermal Generator

Table I. List of Indian Student Satellites

S.No	Satellite Name	Institution	Launch Mass	PSLV	Launch Date
1	ANUSAT	Anna University	40	C12	Apr 20, 2009
2	STUDSAT	Consortium colleges	<1	C15	Jul 12, 2010
3	JUGNU	IIT Kanpur	<3	C18	Oct 12, 2011
4	SRMSAT	SRM University	10.9	C18	Oct 12, 2011
5	SWAYAM	University Pune	1	C34	June 22, 2016
6	Sathyabamasat	Sathyabama University	1.5	C34	June 22, 2016
7	PISAT	PES University	5.25	C35	Sept. 26, 2016
8	PRATHAM	IIT Bombay	10	C35	Sept. 26, 2016
9	NIUSAT	Nurul Islam University	15	C38	June 23, 2017
10	Kalamsat-V2	Space Kids	1.26	C44	Jan. 24, 2019
11	ManipalSAT*	Manipal University	2.0	NA	NA
12	IITMSAT*	IIT Madras	15.0	NA	NA

2. Launched Satellites

2.1. ANUSAT (Anna University Satellite)

ANUSAT holds the distinction of being India's first student-built satellite to be completely designed, fabricated, and tested by Indian students [2]. This collaborative project was undertaken by Anna University, Chennai in partnership with the Indian Space Research Organisation (ISRO) [3]. The satellite's development took place at the Madras Institute of Technology (MIT) campus, which is part of Anna University. A significant characteristic of ANUSAT is that most of its subsystems were implemented using Commercial Off-The-Shelf (COTS) components, demonstrating the feasibility of utilizing readily available commercial parts for space applications. The satellite's configuration is illustrated in Fig. 2, while its key technical specifications are summarized in Table 2. These include details about its mission objectives, dimensions, weight, power systems, and other critical parameters that highlight its design and operational capabilities.

Objectives

The primary objectives of the ANUSAT mission were twofold: first, to foster collaboration among faculty members, researchers, and students at Anna University in the field of space technology, enabling them to work cohesively as a team; second, to provide practical, hands-on experience in the complete development cycle of a microsatellite.

Payload

ANUSAT's payload was specifically designed for data relay operations, capable of transmitting collected information from one location to another. The entire payload system was developed in-house by the team at Anna University, demonstrating indigenous design and fabrication capabilities.

Ground Station

A dedicated ground station was established at the Madras Institute of Technology (MIT) campus of Anna University to support satellite operations. This facility is equipped with comprehensive systems including:

- Telecommand units for satellite control
- Transmitter systems for communication
- Telemetry reception systems with a receiver sensitivity of -110 dBm

The ground station serves as the primary hub for all satellite communication and data acquisition activities.

Fig. 2. ANUSAT

Table II. Key Characteristics Of ANUSAT

Sl. No	**Parameter**	**Value/ system**
1	Payload	Data relay satellite
2	Mass(kg)	38
3	Size (mm^3)	600 x 600x 600
4	Power (W)	40W Body **mounted** GaAs solar cells. Battery: Li-ion 4 x 4 10 AH. Bus Volt: 15.5-16 V
5	Attitude sensor	Sun Sensor, Magnetometer
6	Actuators	Torquers (4.5 AM^2)
7	Stabilization	Spin Stabilized $4\pm$ 0.5 RPM
8	Telecommand	VHF (PCM/FSK/AM); 100 bits/sec, 149.2 MHz.
9	Telemetry	VHF(PCM/FSK/AM); 256 bits/sec., 137.4 MHz,
10	Payload data Transmission	435 MHz
11	Orbit	Inclined
12	Altitude km	550
13	Inclination	41 deg
14	Orbital Time	95.9 min
15	Launch Date	20 April 2009
16	Launch Vehicle	PSLV-C12

2.2. STUDSAT

STUDSAT holds the distinction of being India's second student-developed satellite, created through a collaborative effort among engineering institutions from Bangalore and Hyderabad. The project consortium was spearheaded by Nitte Meenakshi Institute of Technology (NMIT), Bangalore, with participating colleges contributing specialized subsystem development [4]. The complete list of collaborating institutions includes:

Bangalore:

- Nitte Meenakshi Institute of Technology (NMIT)
- M.S. Ramaiah Institute of Technology (MSRIT)
- Rashtreeya Vidyalaya College of Engineering
- B.M.S. Institute of Technology (BMSIT)

Hyderabad:

- Chaitanya Bharathi Institute of Technology (CBIT)
- Institute of Aeronautical Engineering (IARE)
- Vignan Institute of Technology & Science (VITS)

Figure 3 illustrates the STUDSAT-1 spacecraft, while Table 3 summarizes its key technical specifications.

Objectives

The STUDSAT mission pursued two primary goals: first, to advance space technology education within academic institutions; second, to foster research and development in miniaturized satellite design while providing comprehensive project experience from conception through mission completion.

Payload

The satellite incorporated an imaging payload featuring a CMOS detector-based camera system capable of achieving 90-meter spatial resolution.

Ground Station

Mission operations were supported by a dedicated ground station named NASTRAC, established at Nitte Meenakshi Institute of Technology. This facility successfully acquired telemetry data, verifying the satellite's operational status in mission mode.

Fig.3. Image of the STUDSAT-1 CubeSat.

2.3. JUGNU

Jugnu represents a nano-satellite initiative developed by students at the Indian Institute of Technology (IIT) Kanpur [5]. This 3U CubeSat-class satellite was specifically designed for Earth observation applications, with a focus on agricultural monitoring and disaster management. The satellite's configuration and technical specifications are presented in Fig. 4 and Table 4, respectively.

Objectives

The Jugnu mission was conceived with three primary objectives:

1. To engage students in practical space research utilizing MEMS-based technologies with cost-effective implementations
2. To investigate economical solutions applicable to future space missions
3. To demonstrate innovative concepts that could potentially advance satellite design methodologies

Payload

The satellite carries a sophisticated near-infrared (NIR) imaging system featuring:

- A 640 × 480 pixel area array detector
- Spectral range capability of 700–850 nm

- Optical system configuration of F/4 with 35 mm focal length
- Data storage capacity of 2 GB implemented with triple modular redundancy for enhanced reliability

Ground Station

IIT Kanpur established a dedicated ground station with the following operational capabilities:

- Communication system employing Yagi-Uda antenna technology for bidirectional (uplink/downlink) operations
- Custom-developed LabVIEW-based graphical user interface (GUI) for mission control
- Integrated rotary antenna system for enhanced tracking capabilities

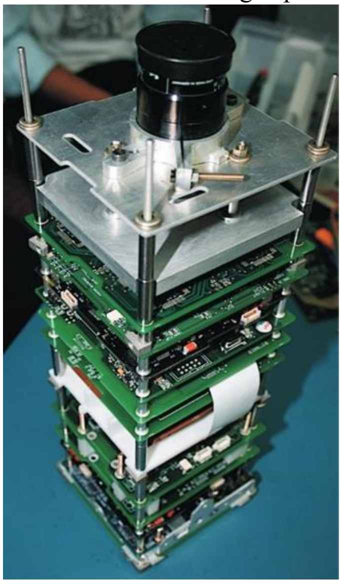

Fig.4. JUGNU without solar panel

Table IV. Key Characteristics Of Jugnu

Sl. No	**Parameter**	**Value/System**
1	Payload	Near IR Camera 640 x 480-pixel Image 197 m resolution
2	Mass(kg)	3
3	Size (mm^3)	10 x 10 x 34 cm^3
4	Power (W)	Solar cells, batteries
5	Attitude sensor	MEMS based IMU
6	Actuators	
7	Stabilization	3 axis stabilization
8	OBC	---
9	TC Uplink TM Downlink Beacon	145.980 MHz 437.505 MHz 437.275 MHz
10	Orbit	Near Equatorial orbit
11	Altitude (km	850 km × 866 km
12	Local time	NA
13	Orbital Period	~102 min
14	Inclination	19.9°
15	Launch Date	12th October 2011
16	Launch vehicle	PSLV-C18

4. SRMSAT

SRMSAT represents a student-developed satellite project undertaken by Sri Ramaswamy Memorial (SRM) University, located in Kattankulathur, Kancheepuram District. The satellite's configuration and technical characteristics are presented in Figure 5 and Table 5 respectively.

Mission

The primary scientific objective of SRMSAT involves atmospheric monitoring, specifically:

- Measurement of greenhouse gas concentrations
- Observation within the near-infrared spectral range (900-1700 nm)

Payload

The satellite carries a specialized grating spectrometer payload designed for:

- Detection of both natural and anthropogenic greenhouse gas sources
- Monitoring of atmospheric carbon sinks
- Spectral analysis of atmospheric constituents

Ground Station

SRM University established a dedicated ground station facility featuring:

- Satellite tracking capabilities
- Telemetry reception systems
- Mission control operations
- The station serves as the primary hub for satellite communication and data acquisition.

2.5. SWAYAM

SWAYAM is a student-developed nanosatellite project designed by undergraduate engineers at the College of Engineering, Pune. As a passive stabilization communication satellite, it features innovative attitude control systems and global messaging capabilities [6]. The satellite's configuration and technical specifications are detailed in Figure 6 and Table 6.

Mission

The SWAYAM mission was designed to achieve three primary goals:

1. Demonstration of passive attitude stabilization techniques in orbit
2. Provision of global point-to-point messaging services for amateur radio (HAM) communities
3. Performance evaluation of UHF communication channels in space environments

Payload

The communication payload incorporates:

- Digital store-and-forward functionality
- Bidirectional message handling capabilities
- Global coverage communication system
- Robust architecture for amateur radio applications

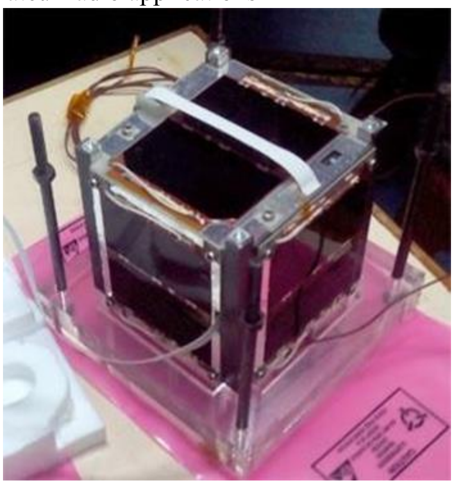

Fig. 6. SWAYAM

Table VI. Key Characteristics Of SWAYAM

Sl. No	Parameter	Value/System
1	Payload	Store and Forward Messaging
2	Mass(kg)	990 g.
3	Size (mm^3)	10 x 10 x 11.35 cm
4	Power (W)	3.3 Solar Cells Batteries
5	Attitude sensor	
6	Actuators	Magnetic torque MEMS gyroscope
7	Stabilization	3 axis stabilisation
8	OBC	---
9	TT Uplink TM Downlink	437.025 MHz
10	Orbit	SSPO
11	Altitude (km)	515
12	Local time	9.30 AM
13	Orbital Period	94.5 min
14	Inclination	97.3 deg
15	Launch Date	22nd June, 2016
16	Launch vehicle	PSLV-C34

2.6. SATYABAMASAT

SATYABAMASAT was designed and built by students at Sathyabama University in Chennai, primarily intended for assessing greenhouse gas levels [7]. The satellite's layout and technical characteristics are shown in Figure 7 and Table 7.

Fig.7. SatyabamaSat

Objective

- To improve educational opportunities for participating students
- To deliver practical experience in designing and building small satellite systems
- To observe and measure atmospheric greenhouse gas concentrations
- To create an Indian pollution model based on information collected by the spectrometer instrument
- To analyze the measurements obtained and display greenhouse gas levels in parts per million (PPM)

Payload

The spacecraft carries an ARGUS 1000 infrared imaging camera that functions in the infrared wavelength range. This camera specifically targets areas relevant to the study, sending information to the On-Board Computer (OBC) during periods when the satellite is within range of the ground station's communication zone. The ground station facility is currently under development at Sathyabama University, Chennai.

Ground Station

A dedicated ground station has been set up at Sathyabama University, Chennai.

Fig.7. SatyabamaSat

Table VII. Key Characteristics Of SATYABAMA Satellite

Sl.No	Parameter	Value/System
1	Payload	Imaging satellites to detect greenhouse gases. (Argus 1000)
2	Mass(kg)	1.779 (2U)
3	Size (mm^3)	10 x 10 x 22 cm
4	Power (W)	3.6
5	Attitude sensor	Sun sensor
6	Actuators	Magnetic torquer
7	Stabilization	3 axis stabilized
8	OBC	ARM 7 Based
9	TT Uplink TM Downlink BEACON	437.980 MHz 145.980 MHz 145.980 MHz
10	Orbit	SSPO
11	Altitude (km)	505
12	Local time	9.30 AM
13	Orbital Period	94.5 min
14	Inclination	97.3 Deg
15	Launch Date	22nd June, 2016
16	Launch vehicle	PSLV-C34

2.7. PISAT

PISAT was developed through a collaborative effort among multiple Indian academic institutions, with PES University taking the lead role. The project received technical support from ISRO (Indian Space Research Organisation) and the Institution of Engineers (India). This student satellite initiative was created to give participants hands-on involvement in complete satellite development and mission operations [8].

Objective

The primary goal was to create a complete space system within an academic setting, with significant contributions from both students and young faculty members.

Payload

PISAT carries a lightweight 166-gram camera system based on CMOS technology, offering 10-bit radiometric resolution. The imaging sensor features a 2048 x 1536 pixel array, enabling it to capture surface areas measuring 185 km by 135 km with a ground resolution of 90 meters.

Ground Station

For satellite communications, the team established a specialized ground facility equipped with a 3.7-meter diameter prime-focus parabolic antenna system.

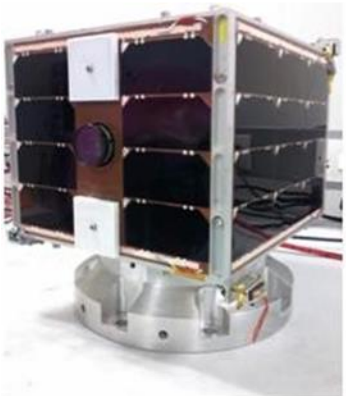

Fig.8. PISAT

Table VIII. Key Characteristics Of PISAT

Sl.No	Parameter	Value/System
1	Payload	Imaging camera
2	Mass(kg)	5 .3
3	Size (mm^3)	254 x 256 x 181
4	Power (W)	13W in sunlit 5.2 Ahr Battery
5	Attitude sensor	Tri-axial MEMS based IMU(Inertial Measurement Unit) and FPSS
6	Actuators	Magnetic Torque Rods
7	Stabilization	Three axis stabilisation
8	OBC	Based on AVR32- AT32UC3A0512 micro controller. Pointing accuracy 5 deg.
9	TCUplink TM Downlink	2030 MHz 2240 MHz
10	Orbit	SSPO
11	Altitude (km)	690
12	Local time	11.30 AM
13	Orbital Period	98.4 min

14	Inclination	98 deg
15	Launch Date	26th Sept 2016
16	Launch vehicle	PSLVC35

2.8. PRATHAM

PRATHAM was created by students from the Indian Institute of Technology (IIT) Bombay [9,10].

Objective

- To give students and faculty practical exposure to satellite and space technologies
- To educate the student team through all phases of satellite creation including design, analysis, manufacturing, testing, and producing the final flight model
- To successfully deploy the satellite and collect Total Electron Count (TEC) data from the ionosphere
- To involve students from other institutions by installing ground stations at their locations

Payload

The spacecraft contains scientific instrumentation to determine the total electron content in Earth's ionospheric region.

Ground Station

The main ground facility is situated atop the Aerospace Engineering Department building at IIT Bombay. A secondary station operates at Atharva College of Engineering. A third reception station was implemented in France by French student collaborators to acquire satellite data.

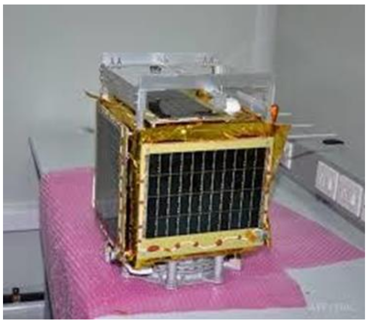

Fig.9. Pratham

Table IX. Key Characteristics Of PRATHAM

Sl. No	Parameter	Value/System
1	Payload	Total Electron Count (TEC) in ionosphere
2	Mass(kg)	10
3	Size (mm^3)	30.5 x 33.5 x 46.6 cm^3
4	Power (W)	13W 6.6 Ahr Battery
5	Attitude sensor	Sun sensor Magnetometer

2.9. NIUSAT

NIUSAT was engineered and constructed by Noorul Islam University in Thuckalay, Kumarakoil, Tamil Nadu [11].

Objective

The mission aims to prepare and develop future aerospace specialists and students pursuing careers in the space sector.

Payload

The satellite incorporates a four-band multispectral imaging sensor with wide coverage. This instrument can obtain images covering 50 km × 50 km areas with 25-meter resolution from its 500 km orbital height.

Ground Station

The ground infrastructure comprises a Mission Control Center and Payload Data Processing Center, featuring a 3-meter diameter antenna system supporting UHF downlink and VHF uplink communications.

Fig.10. NIUSAT

Table IX. Key Characteristics Of NIUSAT

Sl. No	Parameter	Value/System
1	Payload	Imaging camera
2	Mass(kg)	15
3	Size (mm^3)	274 x 274x 195
4	Power (W)	Deployable solar panels with multi junction solar cells generates 40W in sunlit. 10Ah Li-ion battery
5	Attitude sensor	Sun sensors magnetometers, MEMS gyroscopes and star tracker
6	Actuators	Miniature Reaction Wheels and Magnetic torquers
7	Stabilization	3 axis stabilisation
8	OBC	---
9	TC Uplink TM Downlink Payload data	144-148 MHz 420-450 MHz 2240 MHz(S-Band)
10	Orbit	SSPO

11	Altitude (km)	496 x 517
12	Local time	9.30 AM
13	Orbital Period	93 min
14	Inclination	97.45 deg.
15	Launch Date	23rd June, 2017
16	Launch vehicle	PSLV- C34

2.10. KALAMSAT-V2

KALAMSAT-V2 represents a groundbreaking student-built payload named after India's former President, Dr. A.P.J. Abdul Kalam. This mission achieved historical significance by becoming the first to successfully employ the fourth stage of India's Polar Satellite Launch Vehicle (PSLV) as an orbital platform, accomplishing this milestone on January 24, 2019.

3. Satellites Under Development (With ISRO Mou Agreements)

3.1. PARIKSHIT

PARIKSHIT is an upcoming academic satellite project being developed at Manipal Institute of Technology in Karnataka. The institution has established a formal collaboration with ISRO through a Memorandum of Understanding (MoU) for the satellite's eventual launch [12].

3.2. IITMSAT

IITMSAT is a student satellite project under development at the Indian Institute of Technology Madras, with a scientific focus on space weather phenomena and radiation belt studies [13-16].

Objective

The mission aims to study the descent of high-energy electrons and protons from the Van Allen radiation belts to lower orbital altitudes (600-900 km), caused by their interaction with low-frequency electromagnetic waves.

Payload

The spacecraft will be equipped with the SPEED (Space-based Proton Electron Energy Detector) scientific instrument, designed to measure proton and electron flux densities within Earth's magnetospheric region.

4. Follow-up Satellite Mission Activities

4.1 STUDSAT-2

This advanced mission involves a pair of nanosatellites designed to validate the technical feasibility of in-space docking operations between small satellites [17-18].

4.2 PISAT-2

The proposed PISAT-2 spacecraft will feature specialized imaging instrumentation oriented for astronomical observations, targeting detailed studies of stellar objects and celestial bodies.

4.3 SRMSAT-2

The planned SRMSAT-2 represents an ambitious lunar mission with scientific objectives focused on surface characterization and exploration of Earth's moon [19].

5. Satellites Launched Through International Collaborations

KALAMSAT (NASA)

This pioneering 64-gram nanosatellite, named in honor of former President Dr. A.P.J. Abdul Kalam, was developed by a team led by an 18-year-old student from Tamil Nadu. The 3.8 cm cubic satellite featured an innovative 3D-printed carbon fiber composite structure and carried a Geiger-Müller radiation detector. Launched via NASA sounding rocket in June 2017, the mission successfully achieved suborbital spaceflight (reaching space without attaining stable orbit)..

6. Academic Institutions Advancing Space Research

India's premier academic institutions actively contribute to space technology development:

- The Indian Institutes of Technology (IITs) conduct cutting-edge research through specialized aerospace engineering departments
- The Indian Institute of Space Science and Technology (IIST), ISRO's flagship institute, leads numerous international collaborative projects
- IIST's primary research focus encompasses next-generation satellite systems and advanced launch vehicle technologies

1. Balloon-Based Space Experiments

Academic institutions employ cost-effective high-altitude balloon platforms for space technology validation:

2. Periyar Maniammai Institute of Science & Technology (PMIST)

An all-female student team successfully demonstrated balloon-launched payload operations, achieving real-time telemetry transmission to their campus ground station

3. Vellore Institute of Technology (VIT)

During the 2020 National Space Challenge, secondary school participants launched twelve experimental payloads using helium balloon platforms, reaching stratospheric altitudes approaching 20 km

7. Conclusion

The Indian Space Research Organisation (ISRO) has played a pivotal role in cultivating student engagement with space technology development. By providing technical support and launch opportunities, ISRO has enabled engineering students nationwide to acquire practical expertise across the complete satellite lifecycle - from conceptual design and manufacturing to rigorous testing and orbital deployment. This initiative has successfully established a self-sustaining academic space technology environment, with numerous institutions now independently advancing these educational space programs. (Sharma, Jain, & Charhate, n.d., Conference by Antenna Test & Measurement Society).

8. Acknowledgement

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10. Conflict of Interest

The author declares no competing conflict of interest.

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