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Satellite Projects by Indian Students

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Abstract **- Indian Space Research Organization (ISRO) has launched more than hundred satellites for various applications like communication, Earth observation, Astronomy, Navigation, Lunar studies and interplanetary mission from its inception. Addition to its own programmes, it induced Indian student community to make satellites by guiding, providing facilities to test the subsystems and satellites. It also launches these satellites by Polar Satellite Launch Vehicle (PSLV). The student satellite projects provide the design, fabrication, assembly and testing experience of electrical and mechanical systems to university students. It provides experience in project management, budget, schedule and mission planning & operation also. Indian students have launched more than nine satellites so far and some more are under development. Due to this inspiration many Universities/Colleges had flown their satellites through balloons for testing their capabilities. Some students launched their satellites through other space agencies also. This paper presents the salient features of these satellites and technologies used in Indian Student satellites.**

Keywords: Student satellites, Nano satellites, university satellites, Miniaturisation

I. INTRODUCTION

The artificial satellite is a system which mainly goes around the Earth with a specific purpose. It is a multidisciplinary system which can be divided into two main parts based on their functions as payloads and main frame.

Payloads are the instruments or sensors which are directly related to the applications. In the case of Remote sensing satellites, they are cameras/imaging systems, synthetic aperture radars (SAR), scatterometer etc. and in communication satellites they are receivers and transmitters. Some scientific purpose satellites carry instruments to measure the electron contents, gamma ray detectors. X-ray monitors, ultra violet detectors etc.,

The main frame some times called as bus which carries the Payload. It can be broadly divided into electrical and mechanical systems. Electrical subsystems are power system, communication system, data handling digital systems and attitude & orbit control system. The power system generates power from solar radiation in sunlit, stores it in battery for the requirement of eclipse duration operation and distribute the power among different systems. The communication system is to receive the command from the ground stations and transmit various information like temperature, pressure, power consumptions consumption of different systems and attitude and orbit information of the satellites to the ground station. Addition to this it transmits the high volume data collected by payload instruments to the ground. The data handling digital system collects the telemetry information from different systems, format them and transmit to communication system[1]. It also collects the commands from communication systems and distribute to relevant system. Addition to this, the data handling system collect data from payload instruments, compress, encode and send to communication system. The Attitude and orbit control system consists of various sensors and actuators. It measures the attitude and orbit information from sensors and activates the actuators for correction if required.

The spacecraft mechanical systems are structure, thermal control systems (TCS) and mechanisms. The structural system is the skeleton of the satellite, mainly made up of Aluminum alloys and Carbon Fiber Reinforced plastic (CFRP) materials. It provides space to mount the electrical and other mechanical systems. The structure is designed to provide sufficient stiffness to maintain the look angles of the payloads and attitude sensors. The Thermal control system provide suitable thermal environment to the electrical and other mechanical systems for their better functionality. As size of some systems like solar panels and antennas violate the heat shield volume of the launch vehicle. They are to be kept folded during launch and deployed after reaching orbit. For this purpose, some mechanisms are designed and employed. Orbit raising and attitude correction are done by propulsion system.

Many satellites are using chemical propulsion for its high thrust and simple design.

The combination of these mechanical and electrical systems is called as main frame and to support payloads. Each system has interface with other system and all work together to achieve a common goal. The data handling and Attitude and orbit control systems utilize embedded software extensively. The ground systems for satellite tracking and payload data processing involve computing and communication systems with tracking antenna.

The satellite design fabrication and testing need multiple field expertise. Satellite projects provide practical experience for students of many disciplines. As the student satellites are launched as piggy back to main operational satellites, the challenge in fabrication of student satellites lies in making satellites with less mass and small in size.

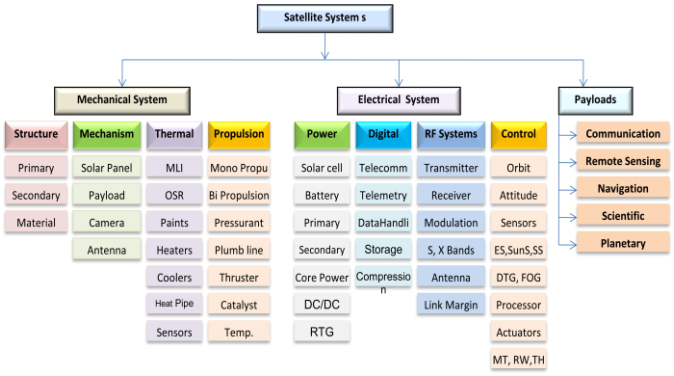

Fig. 1 Subsystems of satellite

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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	

Due to this, student satellites are in mini, cube, pico, nano and micro satellites categories with payloads catering to specific applications. These satellites were designed, fabricated and assembled at corresponding institutions using their funds. ISRO supported in test activities by providing access to its test facilities at UR Rao Satellite centre because the test facilities like thermo vacuum chamber and vibration table are costly. Free launch support was also provided by Polar Satellite Launch vehicle (PSLV). The Fig.-1 provides different subsystems in the satellites and table-1 provides the Names of Indian Student satellites and institutions.

TABLE I. LIST OF INDIAN STUDENT SATELLITES.

Sl.No	Satellite Name	Institution	Launch Mass	Launch Vehicle PSLV	Launch Date
1	ANUSAT	Anna University	40	C12	Apr 20, 2009
2	STUDSAT	Consortium of 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	--		
12	IITMSAT*	IIT Madras	--		

*To be launched

II. LAUNCHED SATELLITES

1. *ANUSAT*

ANna University SATellite (ANUSAT) is the first satellite designed, fabricated and tested by Indian students[2]. It was a cooperative mission of Anna University, Chennai, and Indian Space Research Organization (ISRO)[3]. This satellite was designed and fabricated at Madras Institute of Technology (MIT) campus of Anna University. Most of the sub systems in this satellite are made up of Commercial Off-The-Self (COTS) components.

The Fig.2 shows the satellite and the Table-2 provides the salient features of the ANUSAT.

Fig. 2 ANUSAT

Objective

- To encourage the involvement of the Anna University faculty, researchers and students in Space technologies to work as a team.
- To gain hands-on experience a micro-satellite development

Payload

The ANUSAT Payload was designed to relay the data collected from one place to another place. The payload was designed and fabricated by the Anna University.

TABLE II. SALIENT FEATURES 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+ 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

Ground station

Independent ground station was set up in MIT campus of Anna University and houses the Telecommand, Transmitter

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and Telemetry Receiver systems. The telemetry Receiver sensitivity is -110 dBm.

2. *STUDSAT*

STUDSAT was the second student satellite of India fabricated by a consortium of colleges from Bangalore and Hyderabad. The consortium was led by NIITE Meenakshi Institute of Technology (NMIT), Bangalore. Other colleges contributed by designing and fabricating different subsystems [4]. The list of colleges involved in this project is as follows.

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),

The Fig.3 shows the Studsat-1 and the Table-3 provides the salient features of the STUDSAT.

Fig. 3 Image of the StudSat-1 CubeSat

Objective

- To promote space technology in educational institutions.
- To encourage research and development in the design of a miniaturized satellite along with all the experiences, enthusiasm and efforts necessary to bring such a project to completion

Payload

The STUDSAT payload is a CMOS detector based camera designed to get 90m spatial resolution.

TABLE III. SALIENT FEATURES OF STUDSAT

Sl.No	Parameter	Value/systems
1	Payload	CMOS Camera with 90m Resolution
2	Mass(kg)	1.3
3	Size (mm^3)	100 x 100x 13.5
4	Power (W)	33W, Body mounted Si cells,Li polymer battery 1.24 AH
5	Attitude sensor	Sun Sensor, Magnetometer
6	Actuators	Magnetic Torquers 4.5 AM^2
7	Stabilization	Spin Stabilized 4+ 0.5 RPM
8	OBC	Atmel's ARM based AVR32 UC3A0512 microcontroller
9	TCUplink TM Downlink	145.9 MHz 437 MHz
10	Orbit	SSPO,635 km Altitude Local Time on desc Node
11	Altitude (km)	635
12	Local time	9.30 AM
13	Period	
14	Inclination	87.44º
15	Launch Date	12-July-2010
16	Launch vehicle	PSLV-C15
17	Life Time	Three Months

Ground station

An independent ground station called NASTRAC was setup in Nitte Meenakshi Institute of Technology. It received the Telemetry Data and confirmed the satellite is in mission mode.

3. *JUGNU*

Jugnu is a nano satellite designed and fabricated by students of Indian Institute of Technology (IIT) Kanpur[5]. It is a 3U cubesat aimed to image the earth for Agriculture and disaster monitoring purpose. The Fig.4 and Table-4 provides the view and salient features of the STUDSAT.

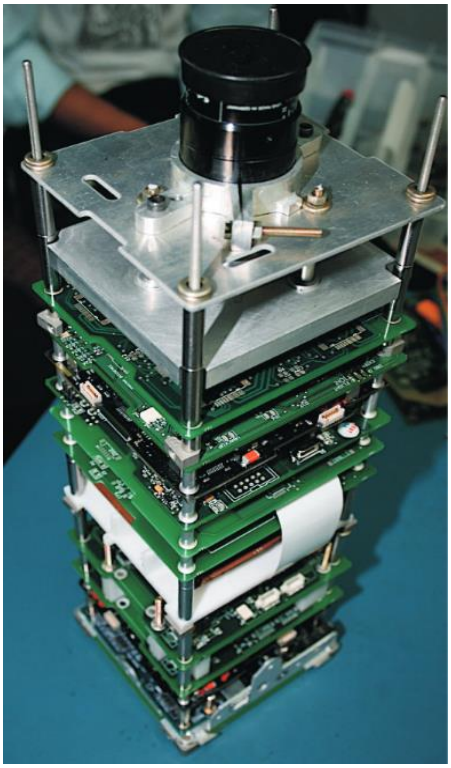

Fig. 4 Jugnu without solar panel

Objective

- To get students involved in research activities based on affordable MEMS technologies
- To test new solutions for the future cost effective space missions
- To set the path for future up gradations and study such validation of concepts

Payload

The JUGNU payload is a near infrared (NIR) camera with 640 x 480 pixel area array detector operating in

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700-850 nm spectral range. It has an F/4 optical system with 35 mm focal length. The acquired data can be stored in 2 Gb Triple modular redundant memory.

TABLE IV. SALIENT FEATURES 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 stabilisation
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

Ground Station

A ground station for monitoring and control has been established in IIT Kanpur. It consists of Yagi-Uda antenna for uplink and down link, GUI interface in Lab VIEW and rotary system.

4. *SRMSAT*

SRMSAT was designed and developed by the students of Sri Ramasamy Memorial (SRM) University, Kattankulathur, Kanchepuram district. The view and salient features of the satellite are provided in Fig.-5 and Table-5 respectively.

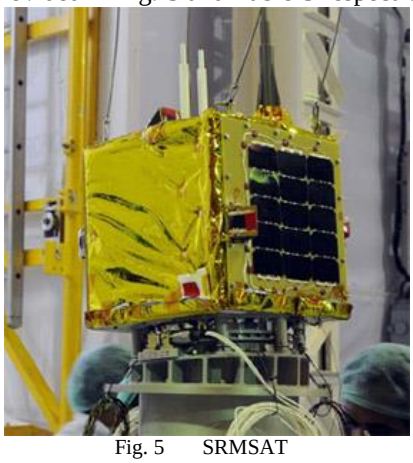

Fig. 5 SRMSAT

Objective

- To monitor green house gases in Near Infrared region 900 nm - 1700 nm.

Payload

SRMSAT Payload is a grating spectrometer for monitoring Earth-based sources and sinks of anthropogenic and natural sources of greenhouse gases.

TABLE V. SALIENT FEATURES OF SRMSAT

Sl.No	Parameter	Value/ System
1	Payload	Near IR Camera 640 x 480 pixel Image 161 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	IMU
6	Actuators	Magnetic Torquer
7	Stabilization	3 axis stabilisation
8	OBC	---
9	TCUplink TM Downlink	437.505 MHz (UHF) 145.98 MHz(VHF)
10	Orbit	SSPO
11	Altitude (km)	860 km
12	Local time	9.30 AM
13	Orbital Period	102 min
14	Inclination	19.9°
15	Launch Date	12th October 2011
16	Launch vehicle	PSLV-C18

Ground Station

The SRMSAT team setup aground station at the SRM University Kattankulathur campus and tracked the satellite

5. *SWAYAM*

Swayam a passive stabilization communication Satellite was developed by undergraduate students of College of Engineering, Pune. The payload flown on this satellite is to support point to point communication[6]. User can send and receive messages from one point to other point on the earth. The view and salient features of the satellite are provided in Fig.6 and Table-6 respectively.

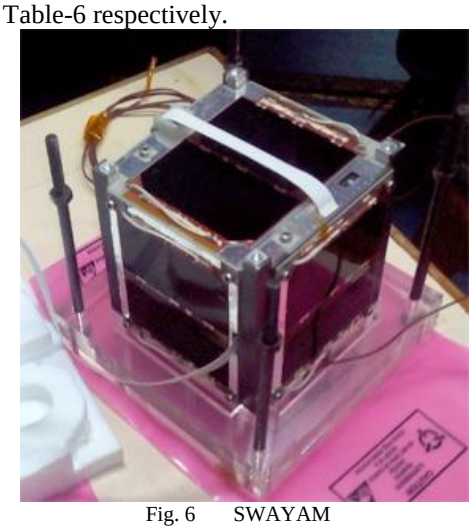

Fig. 6 SWAYAM

Objective

- To demonstrate passive attitude control.

To provide point to point messaging services to the HAM Community using a bidirectional communication satellite.

UHF channel performance evaluation develop a bidirectional communication satellite.

Payload

The payload was designed to support message store and forward.

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TABLE VI. SALIENT FEATURES 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

6. *SATYABAMASAT*

The satyabamasatellite was designed and fabricated by the students of Sathyabama university, Chennai to measure the concentration of green house effect gases [7]. The satellite is shown in Fig.7 and the salient feature of the satellite are provided in Table-7

Fig. 7 SathyabamaSat

Objective

- To maximize the learning experience of the students
- To provide a real-time design and development experience for the students on compact space systems.
- To monitor the concentration of green house gases present in the atmosphere.
- To obtain the pollution model for India through the data collected using spectrometer payload.
- To interpret the acquired data and represent the concentration of greenhouse gases in PPM.

Payload

It is an imaging camera (ARGUS 1000) operated in Infrared spectral region. The payload is operated only over the regions where the experimentations are interested, and it delivers the data to the On-Board Computer (OBC) for transmission, when it crosses the radio window of ground station, which is being built in Sathyabama University campus, Chennai, India.

TABLE VII. SALIENT FEATURES OF SATHYABAMA SATELLITE

Sl.No	**Parameter**	**Value/System**
1	Payload	Imaging satellite to detect green house 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

Ground Station

Ground station is established in Sathyabama university, Chennai.

7. *PISAT*

PISAT was designed and fabricated by a consortium of Indian colleges led by PES University, with the support of ISRO (Indian Space Research Organization) and IE (Institution of Engineers) of India to provide a hands-on environment for students in all aspects of satellite building and operations[8].

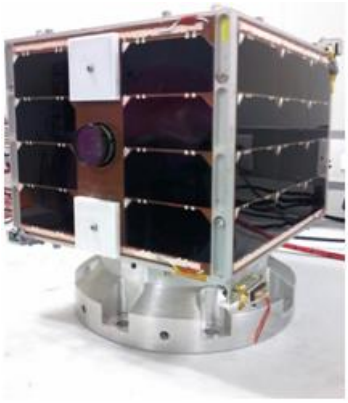

Fig. 8 PISAT

Objective

- To develop, design a space system in university environment with our students and young faculty.

Payload

The PISAT payload is a 166 gm CMOS based camera with 10-bit radiometric resolution. It has an area array detector with 2048 H x 1536 V pixels. This covers 185 km x 135 km area with 90 m spatial resolution.

TABLE VIII. SALIENT FEATURES 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

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Sl.No	Parameter	Value/System
		(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

Ground station

PISAT team has developed a ground station with 3/7m paraboloid antenna with prime focus.

8. *PRATHAM*

This satellite was designed and fabricated by Indian Institute of Technology (IIT) Bombay Students[9,10].

Fig. 9 PRATHAM

Objective

- To enable students and faculty to gain knowledge and experience in the field of Satellite and Space Technology.
- To empower the Satellite Team with the skills to develop the Satellite through various phases of Design, Analysis, Fabrication and Testing until the Flight Model is made.
- To launch the satellite into orbit and measuring Total Electron Count of the Ionosphere.
- To involve students from other universities in our Satellite mission by building ground stations in their universities.

Payload

The PRATHAM Payload is designed to derive the total electron count in the ionosphere.

TABLE IX. SALIENT FEATURES 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
6	Actuators	Magnetic Torquer
7	Stabilization	3 Axis stabilised
8	OBC	---
9	TCUplink TM Downlink Beacon	No uplink 437 MHz 145.98 MHz
10	Orbit	SSPO
11	Altitude (km)	670
12	Local time	1.30 AM
13	Orbital Period	98.4 min
14	Inclination	98 deg
15	Launch Date	26th Sept 2016
16	Launch vehicle	PSLV- C35

Ground Station

Separate ground station is established at roof top of Aerospace department. in IIT Mumbai. Atharva college of engineering also established a ground station for Pratham One ground station was setup in France by French students to receive data from Pratham.

9. *NIUSAT*

This satellite was designed and fabricated by Noorul Islam University, thuckalay, Kumarakoil, Tamilnadu[11].

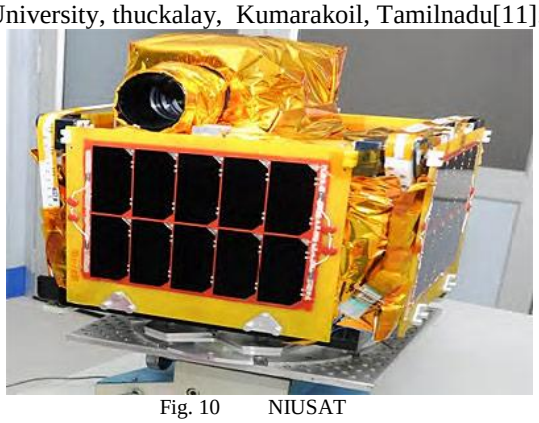

Fig. 10 NIUSAT

Objective

- To enable new entrants in the industry/next generation students and aerospace aspirants.

Payload

The NIUSAT payload is a four spectral band wide field Sensor. It covers 50 x 50 km and 25m resolution from the altitude of ~500 km

TABLE X. SALIENT FEATURES 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

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Sl.No	Parameter	Value/System
13	Orbital Period	93 min
14	Inclination	97.45 deg.
15	Launch Date	23rd June, 2017
16	Launch vehicle	PSLV- C34

Ground station

The NIUSAT ground station consists of mission control centre and Payload data processing centre. It has a three meter antenna which supports UHF downlink and VHF Uplink.

10. KALAMSAT-V2

The KalamsatV2, payload named after former Indian president APJ Abdul Kalam is the first to use the fourth stage of PSLV as an orbital platform. 24th January 2019. This payload was developed by students and Chennai-based Space Kidz India. The satellite is the smallest weighing 1.2 kg and has a lifespan of two months.

III. SATELLITES UNDER DEVELOPMENT(MOU WITH ISRO)

1. PARIKSHIT

Parikshit is being developed by Manipal Institute of technology, Manipal, Karnataka. MOU is signed with ISRO for the launch of this satellite[12].

2. IITMSAT

IITMSAT is being developed by students of Indian Institute of Technology (IIT) Madras [13-16].

Objective

- The objective is to study the precipitation of high energy electrons and protons from Van-Allen radiation belts to lower altitude of 600-900 km due to resonance interaction with low frequency EM waves.

Payload

IITMSAT will carry Space based Proton Electron Energy Detector (SPEED) instrument as payload to measure proton and electron fluxes in the Earth's magnetosphere.

IV. CONTINUATION SATELLITES PROJECTS

Some educational institutions are proposing to launch satellites. Satellites and the Institutions are listed in Table-11

TABLE XI. CONTINUATION SATELLITE PROJECTS

Satellite	Institution
STUDSAT-2	Nitte Meenakshi college
PISAT-2	PES institute of Technology
SRMSAT-2	SRM University

1. STUDSAT-2

The studsat-2 project is proposed with two nanosatellites to prove the capability of nanosatellites in docking experiment in space[17-18].

2. PISAT-2

PISAT-2 is proposed with imager which may point towards space for the study on stars.

3. SRMSAT-2

SRMSAT-2 is proposed to reach moon and have a study on the moon surface[19].

V. SATELLITES LAUNCHED BY OTHER AGENCIES

1. KALAMSAT

The Kalamsat, named after former Indian President Abdul Kalam, weighing 64 grams was designed and developed by 18-year old Tamil Nadu student and his team. This satellite is 3.8 cm cube with 3-D printed reinforced carbon fiber structure. The instrument carried by this satellite was Geiger Muller counter. This satellite was launched by NASA's sounding Rocket in June 2017. Sub-orbital spaceflights technically enter space, but do not get into orbit.

VI. INSTITUTIONS INVOLVED IN SPACE STUDIES

Many Indian Institutes of Technologies have involved in space related studies through their various departments.

Indian institute of space science and technology (IIST) which is under Indian Space research Organization is carrying out many space related research in collaboration with other universities in India and abroad. Mainly it focuses in developing new technologies required for future satellites and launch vehicles.

1. SATELLITES LAUNCHED WITH BALLOONS

Many colleges have started the satellite systems study and testing their systems by launching them using balloons. Some colleges are mentioned below as samples.

2. PERIYAR MANIAMMAI INSTITUTE OF SCIENCE TECHNOLOGY (DEEMED TO BE UNIVERSITY)

A team of girls of Periyar Maniammai Institute of Science Technology (Deemed to be University), Vallam, launched a satellite using helium-filled balloon. The satellite was capable of sending live telemetry consisting of data and flight parameters to the control station at PMIST premises.

3. VELLORE INSTITUTE OF TECHNOLOGY (VIT)

Twelve payloads with satellite bus were launched using a helium-filled balloon by school students during the National Space Challenge-2020 (NNSC)from Vellore Institute of Technology(VIT). The balloon was expected to reach an altitude of 20 kilometers.

VII. CONCLUSION

The Indian Space Research Organisation (ISRO) has created Space systems awareness among Indian Students and helped in design, fabrication, testing and launch of satellites developed by Indian students. Now many colleges continuing the space study autonomously.

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