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YOUTHSAT

Involving Young Minds in Space Technology & Research

IRS & SSS PROGRAMME MANAGEMENT OFFICE
ISRO SATELLITE CENTRE
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Introduction

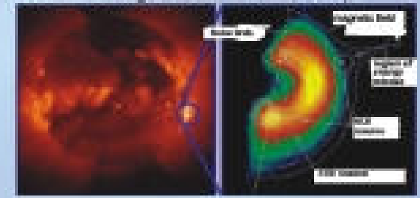
Indian Mini Satellite -1 bus has been developed as a standard bus of 100 kg class which includes a payload capability of around 30 kg. The spacecraft bus has been developed as a versatile bus in order to carry different payloads without significant changes in the bus. It offers a very quick turn-around time and low cost means of demonstrating, verifying and evaluating new technologies. The first mission of the IMS-1 series was launched successfully on April 28th 2008 as a co-passenger along with Cartosat 2A onboard PSLV C9. Two payloads namely Multi Spectral Camera and Hyper Spectral Camera were flown successfully on IMS-1. Several promising new technologies that have been implemented in this mission have been qualified after its successful completion of two year mission life.

YOUTHSAT is second in this series, carrying three payloads namely SOLRAD, LiVHySI and RaBIT. It is planned to be launched on PSLV-16 as co-passenger along with Resourcesat-2 into 817 kms – Sun Synchronous Orbit at a nominal local time of 10:30 am. The payload data collected will be used for scientific studies like research of solar activity, mapping the Total Electron Content (TEC) of the Ionosphere and performing airglow measurements of the earth's atmosphere.

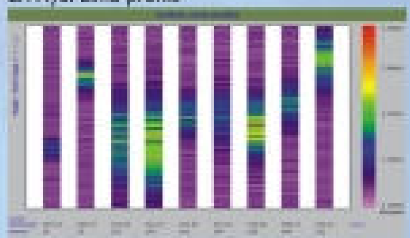
Orbit specifications of Youthsat:

Semi Major Axis (Kms)	: 7195.12
Altitude (Kms)	: 820 ± 20
Eccentricity	: 0.001
Inclination (deg)	: 98.731 ± 0.2
Argument of Perigee (frozen)	: 90.0
No of orbits per day	: 14 5/24
No of orbits / cycle	: 341
Orbit Period(min)	: 101.35
Local time @ descending node	: 10.30 am
Repeativity (days)	: 24
Ground track maintenance (km)	: +/- 10

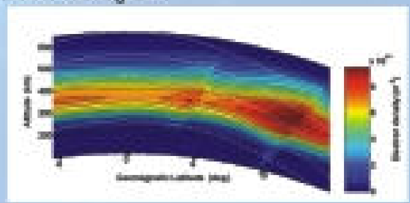
Solar flare images in soft and hard X-rays



LiVHySI Limb profile



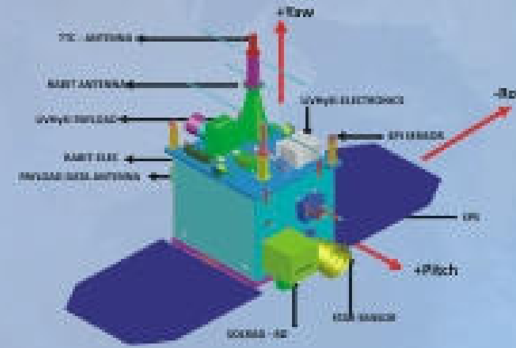
RaBIT Tomogram



The SOLRAD payload onboard Youthsat would be continuously monitoring the Solar activities (like flare and CME events) through hard X-rays, γ-rays and particle (mostly electrons and protons) detectors. The effects of these solar activities on ionosphere would be studied by RaBIT and the effects on the thermosphere, which co-exists with the ionosphere, by LiVHySI. All the three payloads put together form a unique and comprehensive package of experiment for the investigation of the composition, energetic and dynamics of upper atmosphere. The combination of LiVHySI and RaBIT would provide excellent simultaneous measurements of neutral and plasma parameters respectively, complementing each other and also the solar radiation measurements through SOLRAD. Both these Indian experiments are the first of its kind indigenously built onboard an Indian satellite.

Spacecraft

Youthsat is built around IMS-1 Bus and all the mainframe elements are inherited from this bus except for few systems. IMS-1 Bus is a three axis stabilized 100 kg class bus, built in single system configuration.



Youthsat Spacecraft Mainframe Specifications:

Bus	:	IMS-1 Bus
Mission Life	:	2 years
Spacecraft lift of Mass	:	92.8 Kg
Spacecraft Power Consumption	:	90W Continuous, 140W Peak
Data Handling		
Data rate	:	8 Mbps
Recorder	:	16 Gb Solid State Recorder
RF Systems		
Downlink	:	S-Band Transmitter for Payload Science Data (5W, 8Mbps, PCM/BPSK) S-Band Transmitter for TM Data (100 mW, 4Kbps, PCM/BPSK)
Uplink	:	S-Band Tele command Receiver (100bps, PCM/ FSK /FM)
SPS	:	12 channel, 20m (Position accuracy), 0.25 m/s (Velocity accuracy)
AOCS		
Stabilization	:	3 axis stabilization
Pointing Accuracy	:	0.1 deg
Drift rate	:	5.0×10^{-4} deg /sec
BMU	:	Attitude and Orbit control; TM /TC handling
Sensors	:	Single Head Mark 2 Star Sensor, Tri axial Magnetometer Miniature DTG (2 nos), 4 pi Sun Sensors (4 heads)
Actuators	:	Micro Reaction Wheels (4nos, Ang Momentum: 0.36 Nms, Reac torque: .015Nm) Magnetic Torquers (2 nos, Capacity 9 A-m²)
Propulsion	:	Monopropellant System Single 1N thruster, Centrally Mounted single Tank (3.5 Kg Fuel)
Power		
Solar Panels	:	Two deployable Sun pointing Solar panels (Triple Junction solar cells) generating 230 W power (EOL)
Battery	:	10.5 AH Lithium Ion battery
Raw Bus	:	28 - 33V
Distribution	:	Centralized Power Distribution Scheme
Mechanism	:	Solar Panel Hold Down and Release Mechanism (Paraffin Actuator)

YOUTHSAT

SOLRAD Payload

SOLRAD (Solar Radiation Experiment) is a co-operative joint scientific mission between India and Russia with participation of youth from both the countries.

Detector box SOLRAD-BD

Information box SOLRAD-BI

Scientific goals: SOLRAD instrument is designed in SINP MSU (Skobel'tsyn Institute of Nuclear Physics Moscow State University) to study time variations of solar X-ray and Gamma-ray flux and spectra as well as the variations of the flux of charged particles generated in the Sun or in the Earth vicinity. Astrophysical gamma-ray bursts and some variable sources can be also studied.

The goal is research of solar flare activity by measuring temporal and spectral parameters of solar flare X-rays and Gamma rays as well as of charge particle (electron and protons) fluxes in the Earth Polar cap regions which are sensitive to solar flare activity. The scientific objectives are met with an X-ray and Gamma ray detector – spectrometer system using a NaI (Tl) / Cs (Tl) phoswich unit and a charged particle detector system using a silicon detector telescope unit.

SOLRAD payload consists of two modules namely Detector module and Electronics module. The Detector module consists of two independent units: Detector Unit for Electrons (DUE) and Detector Unit for X-rays and Gamma (DUXG). Based on the scientific objective, SOLRAD payload has to be pointing towards Sun during Sun Pointing period of the orbit.

The phenomena to be studied with SOLRAD particle detector are:

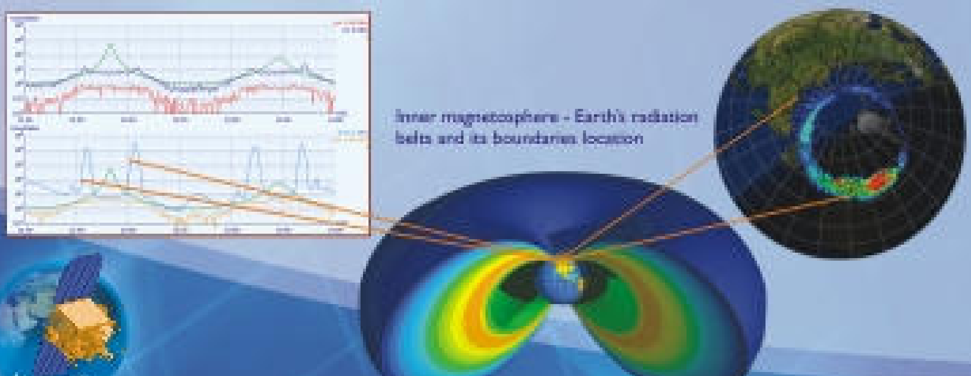
- SEP events and solar charged particle penetration boundaries in the Earth's magnetosphere during geomagnetic disturbances;
- Dynamics of the relativistic electron fluxes in the Earth's magnetosphere;
- Energetic particle precipitation under the Earth's radiation belts (at low and high latitudes).

The phenomena to be studied with SOLRAD X-ray and Gamma detector are:

- Fast X-ray and Gamma-ray flux variations
- Thermal and non-thermal part of X-ray and Gamma-ray spectra
- Gamma-ray lines
- Astrophysical gamma-ray bursts (GRB)
- X-ray binaries, pulsars, SGR, etc

Detector Unit

SOLRAD payload is always kept ON throughout the time in the orbit irrespective of the attitude geometry. SOLRAD payload data is stored in its internal memory. SOLRAD payload has a provision onboard to store the last 20 sessions payload data, which can be played back on requirement by issuing a SOLRAD multi data command appropriately. The estimated data volume is 100 Mbytes/day.



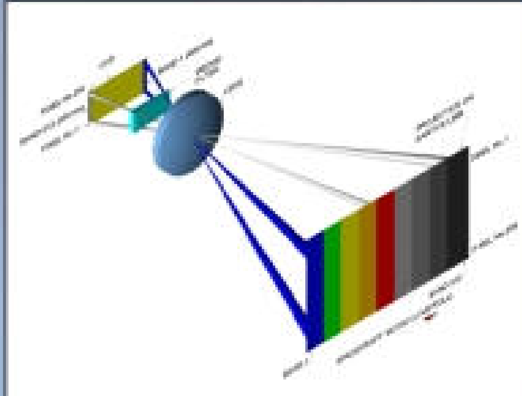
Inner magnetosphere - Earth's radiation belts and its boundaries location

LiVHySI Payload

The 'Limb Viewing Hyper Spectral Imager' referenced to as LiVHySI would be continuously imaging the earth's limb along the meridian between ~ 80-600 km as it moves in the polar orbit. The atmosphere in this altitude region is emanating a range of prominent airglow emissions at different wavelengths maximizing at different heights. These atmospheric emissions are known as 'Airglow'. They serve as a perfect tracer for the processes occurring in the altitude regions from which they emanate.

The main objective of the instrument is to perform airglow measurements in the Earth's upper atmosphere (80 to 600 km) in a spectral range of 450 nm to 950 nm. The observations would be carried out in the earth's limb viewing mode with a range of about 3172 km from a LEO sun-synchronous polar orbital platform (altitude of 817 km). Sensor Development Area (SEDA) at Space Applications Centre(SAC) has developed this Hyper-spectral Imager. The earth's limb viewing geometry rather than nadir viewing geometry is chosen because the horizontal line of sight through the earth's limb contains upto sixty times more emitting material than a corresponding nadir view, thus providing greater sensitivity.

Imaging System: The imaging system of LiVHySI consists of collecting optics, a wedge filter, 512*256 elements Silicon based APS (Active Pixel Sensor) area array and associated electronics. The 256 pixels side of the detector would be aligned vertically ('Yaw axis) along the altitude axis, while the 512 pixel side of the detector would be employed horizontally (Band 1 is along +Roll side, Band 512 is along –Roll side). In this configuration, the imaged airglow emissions would not only provide the altitude distribution of the emitting species but also give us an insight into the physical, chemical and transport processes operating at different altitude regimes of upper atmosphere.



SCHEMATIC OF SPECTRAL BAND PROJECTION ON EARTH'S LIMB

Specifications:

IGFOV	:	2.0 km at Range 3172 km
Altitude Coverage	:	80 Km to 600 Km
Horizontal Swath	:	1024 km
Vertical Swath	:	512 km
Spectral Coverage	:	450 nm to 950 nm
Spectral Sampling	:	1.1 nm
Spectral BW	:	<25nm
Noise equivalent signal	:	<50 Raleigh at T_{int}:10s
Integration time	:	Selectable 1s to 20s
Data Rate	:	4 Mbps

RaBIT Payload

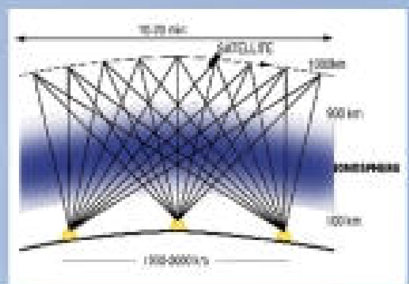
Scientific Objectives: The main objective of RaBIT payload (Radio Beacon for Ionosphere Tomography) is to measure the Total Electron Content (TEC) of the Ionosphere. The position accuracy achievable from navigation satellites is largely affected by the intervening ionosphere. The range error is directly proportional to the total electron content along the ray path. Ionospheric tomography is a powerful tool to address the spatial variability of the ionosphere. The advantage is that it gives a snapshot picture of the latitude, altitude variation of the ionosphere. The basic data for this is the line of sight TEC (STEC).

RaBIT Payload

RaBIT Transmitter onboard the satellite will generate and transmit to ground, two phase coherent frequencies, 150 MHz and 400 MHz at a power level of +30 dBm. The ground receivers measures the phase difference between the incoming signals, and the TEC is estimated by the method of Differential Doppler Technique. The receiver chain for Indian region is along 77-78° longitude from Trivandrum to Delhi and for Russian region along 84-87° longitude. In order to meet the envelope constraints, the antenna is stowed during the launch and deployed after injection using Nylon Rope Cutter Mechanism.

The TEC data obtained at all the ground stations will be kept at ISSDC (Indian Space Science Data Centre). The final product viz. The Ionospheric Tomogram over the Indian and Russian regions will be generated using the VTEC measured at each station, and kept at ISSDC for Users.

Indian Block of Stations:		
Station	Lat. (°N)	Long. (°E)
Trivandrum	8.5	77.0
Bangalore	13	77.6
Hyderabad	17.8	78.0
Bhopal	23.2	77.2
Delhi	28.6	77.2



Ground Segment

On-board automation of payload scheduling is planned for the first time in Youthsat to make the payload operations fully autonomous and also to reduce the ground commanding load. Automation of Payload Sequencer involves AOS LOS Computation, Eclipse Entry and Exit Times Computation, Payload Sequencer Automation Scheduler and Command generation.

Nominally all the three payloads are operated on time sharing basis. SOLRAD payload is always ON and its requirement of pointing towards Sun is met only when the spacecraft follows Sun pointing attitude definition. LiVHySI payload is planned to be operated in all eclipses (Limb Viewing Attitude Definition is followed), except the Indian ascending eclipse pass where RaBIT payload is operated. RaBIT payload is planned to be operated in both descending and ascending Indian passes over Russian and Indian stations where the spacecraft will follow Station viewing attitude orientation. On-board analytical algorithms will compute the station AOS/LOS times and eclipse Entry/Exit times which will be used by the scheduling algorithm to plan the payload operations. Playback planning of SOLRAD and LiVHySI payloads along with telemetry data (HK) is done automatically onboard based on the visibility duration availability.

The ground segment elements are spacecraft control center, payload operations, data reception & payload data acquisition, Level-0 operations, data processing facility, data products generation, archival and dissemination to meet the mission requirements. The RaBIT data will be collected by intended set of stations and the data transferred to ISSDC. The data from other two payloads, along with HK-PB will be received at Bangalore station and moved to ISSDC. Youthsat will be controlled through Bangalore ISTRAC Network Station.

GROUND SEGMENT CONFIGURATION OVERVIEW OF YOUTHSAT