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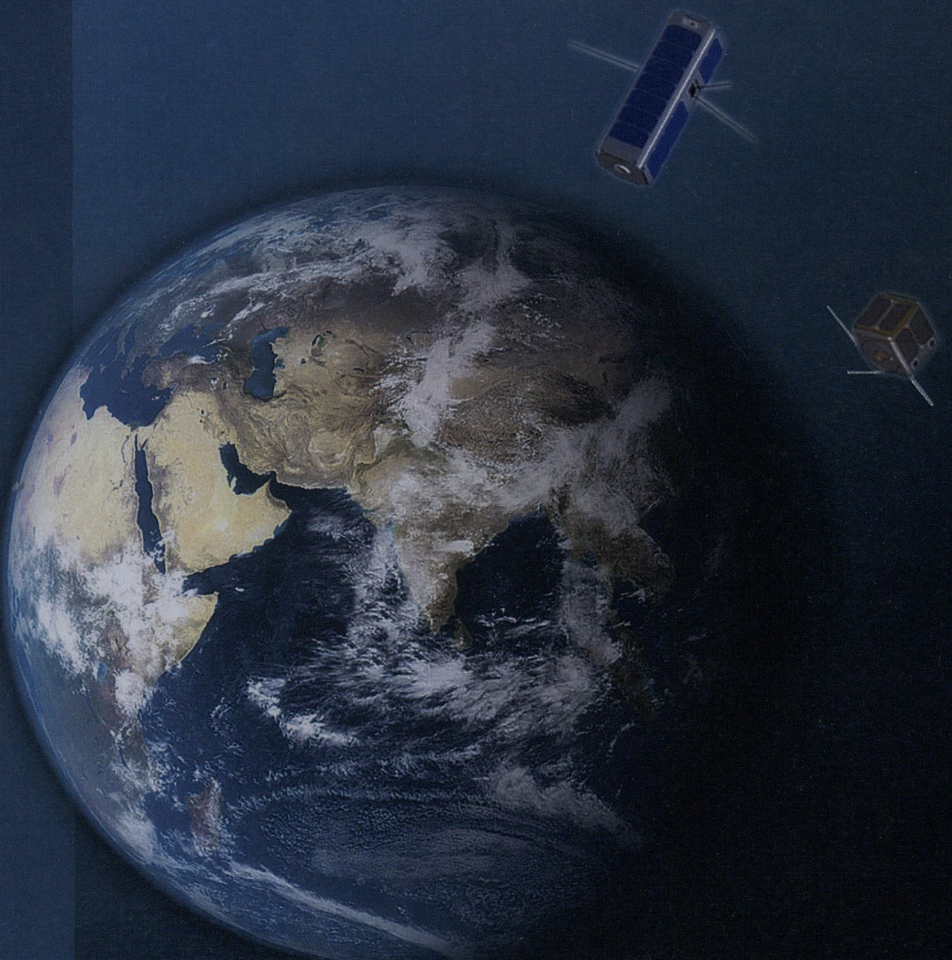
GUIDELINES FOR STUDENT SATELLITE PROPOSAL



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ISRO Satellite Centre
Indian Space Research Organisation
Bangalore

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GUIDELINES FOR STUDENT SATELLITE PROPOSAL

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ISRO SATELLITE CENTRE

INDIAN SPACE RESEARCH ORGANIZATION

BANGALORE - 17

PURPOSE OF THIS DOCUMENT

This document is released to guide Universities/Institutions in preparing 'Student satellite proposal'. This document lists the minimum information required to be provided in proposal document. This document also indicates the work (design realization, testing, reviews, ground segment and documentation etc.) involved in making satellite.

The conditions, contents and criteria for selection given in this document may vary with time based on ISRO's experience in student satellite program. The budget information and schedules given in this document are only examples. Actual budget and schedule may vary with respect to the size, complexity and technology involved apart from the project management structure in University/Institution.

The system specification, tests and documents mentioned here is typical in nature. Actual number and type of tests and documents to be prepared may vary based on proposed satellite configuration. Further clarity comes during actual reviews.

This document is a guidelines document for proposal and has no legal binding on ISRO.

PREFACE

Efforts of international space agencies in serving the society in the fields of communication, remote sensing, and astronomy using satellites have attracted the universities & educational institutions and influenced them to include the satellite technologies and applications in their curriculum.

Traditional operational satellites are very expensive in nature because of their usage of radiation hardened electronic components and their redundancy concept in design to achieve high reliability and long lifetime.

The advancement of technology in each and every field either mechanical or electrical has provided ways to miniature systems in terms of size, power and mass. As most of small satellites are experimental in nature there is no need for providing redundancy and have high reliability which extends the life of the mission. Miniaturization of satellite helps not only in reduction of satellite cost as it reduces the launch cost and improves launch opportunities as well.

The space agencies of advanced countries extend their help to the universities to make experimental satellites as the part of their curriculum. They help the Universities in making satellites for experimental studies and research.

ISRO also has influenced educational institutions by its activities like making satellites for communication, remote sensing and astronomy. The launch of chandrayaan-1 increased the interest of universities and institutions towards making experimental student satellites. As a result, the following student satellites were fabricated and launched with the guidance of ISRO.

1. Anusat - Anna University, Chennai
2. Studsat - NMIT College and others, Bangalore
3. Jugnu - IIT Kanpur
4. SRMSAT - SRM University, Chennai

Based on the success of the above satellite missions, more and more Indian universities and educational institutions are showing interest in participating in student satellite programme. Also, based on the experience gained in above projects, ISRO felt the need to frame uniform guidelines for student satellite projects to streamline this area.

This manual has two parts. The first part provides introduction to the student satellite project in terms of technology, review methods, budget requirement, time schedule and responsibilities of Indian universities or Institutions. The second part provides guidelines for preparing proposal and to make MOU with ISRO.

Abbreviations

4 Pi SS	4 Pi Sun sensor
ADC	Analog to Digital Converter
AH	Ampere Hour
AHB	Advanced High speed Bus
AIT	Assembly Integration & Testing
Al	Aluminium alloy
AMBA	Advanced Micro control Bus Architecture
AOCS	Attitude and Orbit Control System
APB	Advanced Peripheral Bus
ASIC	Application Specific Integrated Circuit
ATJ	Advanced Triple Junction
BDH	Baseband Data Handling
BDR	Baseline Design Review
BOL	Beginning Of Life
CAN	Controller Area Network
CDR	Critical Design Review
COTS	Commercial - Off –The- Self
dB	Decibel
EM	Engineering Model
EOL	End Of Life
FM	Flight Model
FPGA	Field Programmable Gate Array
FRR	Flight Readiness Review
FSK	Frequency Shift Keying
G/T	Gain/Temperature
GPS	Global Positioning System
HILS	Hardware In-Loop simulation facility
HK	House Keeping
IISU	ISRO Inertial Systems Unit
IRU	Inertial reference unit
ISRO	Indian Space Research Organization
IST	Integrated Spacecraft Testing
ISTRAC	ISRO Telemetry Tracking and Command Network
Li-ion	Lithium ion
MLI	Multi-Layer Insulation
MRR	Mission Readiness Review
MTC	Magnetic Torquer Coil
MX	Multispectral
OBC	On-Board Computer
OILS	Onboard Software In Loop Simulation
OSR	Optical Solar Reflector
P	Pitch axis
PCB	Printed Circuit Board

PCM	Pulse Code Modulation
PDR	Preliminary Design Review
PMO	Programme Management Office
PROM	Programmable Read Only Memory
PSK	Phase Shift Keying
PSLV	Polar Satellite Launch Vehicle
PSR	Pre-Shipment Review
R	Roll axis
RAM	Random Access Memory
RF	Radio Frequency
RISC	Reduced Instruction Set Computing
ROM	Read Only Memory
RW	Reaction Wheel
Rx	Receiver
SNR	Signal to Noise Ratio
SoC	System On Chip
SPS	Satellite Positioning System
TC	Telecommand
TTC	Telemetry Tracking and Command
Tx	Transmitter
UHF	Ultra high Frequency
USB	Universal Serial Bus
VHDL	Very high speed Hardware Description Language
VHF	Very High Frequency
VSSC	Vikram Sarabhai Space Centre
Y	Yaw axis

Part-1

INTRODUCTION

TO

PARTICIPATION OPPORTUNITIES
IN SPACE ACTIVITIES
FOR INDIAN UNIVERSITIES / INSTITUTES

CONTENTS

Part-2A **Payload design and fabrication by Universities / Institutions**

Part-2B **Satellite fabrication as per ISRO's design**

Part-2C **Satellite design and fabrication by Universities/ Institutions**

1 INTRODUCTION

ISRO supports Universities and Institutions in development of Student Satellites. The electronic systems a few decades back have been large in size & weight, and were consuming more power. The conventional satellites designed and developed were no exception. With the advancement of electronic technologies and miniaturization the systems have kept shrinking occupying very low volume, having low mass, consuming unbelievably low power, yet sometimes performing better than earlier systems. This revolution in electronics and embedded systems has generated a breed of high performance small satellites. This has a lead to standardization and categorization of satellites according to their weights.

The international standards for small satellites are

Small satellite	<1000Kg
Mini satellite	100Kg to 500 Kg
Micro satellite	15 to 100Kg
Nano satellite	1Kg to 15Kg
Pico satellite	100g to 1Kg
Femto	1g to 100g

The earlier satellites of 1000Kg to 1500Kg operational missions could be successfully realized in micro and mini satellites weighing one order less and built with components of quality to serve two to five years missions, including scientific and experimental missions. These missions with reduced cost have become achievable and affordable for developing countries that were not able to venture into the space services market earlier. Also due to lower number of components the reliability has also improved reasonably giving scope for realizing good application mission.

The satellites have predominantly become useful for experimental, demonstration and primarily educational mission due to much lower cost, affordable by universities and Institutions.

These satellites have also become good training ground for providing the on hand experience which is an effective way of education and knowledge transfer to the academic community. This educational initiative has not only become a strength or capacity building activity but also for initiation of academic course in space technology in many Institutions all over the world.

ISRO envisioned this area of activity a decade back and initiated small satellites development within ISRO for scientific, experimental, as well as operational purpose. Parallelly, the development of Nano satellites were encouraged as a part of capacity building and several such satellites were built and launched.

Modern technology and advanced engineering techniques have allowed for nano satellites and nano satellite components which are capable of performing variety of missions. Nearly every subsystem of a spacecraft can be reduced in size through advances in technologies. Of these subsystems, computers and electronics play a vital role as the central nervous system of most satellites. Nano satellite designs benefit from smaller scale electronics, giving them more on orbit processing and more autonomy at a fraction of the weight.

There are several advantages in using Nano satellites in space missions, of which the most significant ones are:

- Since the student satellites are of low mass, the launch cost can be kept low. In addition, these can be launched as 'piggy-back rides' with launches of larger operational satellites.
- Miniaturization of system by using FPGAs and ASIC reduce the weight & Size and also improve the performance of the system. Further, the thermal control issue will be scaled down.
- The latest technology and low cost allows shorter lifetime missions (ranging from days to about one year) to use Industrial quality level components. COTS products may be employed for the same reason, thus significantly contributing to the reduction of mission cost.
- The relatively short development time for a Student satellite allows more missions to be flown with the latest technology, since the cost for each mission is accordingly reduced.
- As the satellites are small, they can be mass produced in an assembly line fashion, a technique which is impossible for larger satellites.
- The use of Student satellites reduces the problem of space debris, since the satellites are smaller and de-orbit faster.

Some applications of Student satellites are:

- Pre-configured constellation of Student satellites can be used for contingency operations, support communications in regions for military operations, natural disasters or other emergency situations.
- Study of magnetosphere by number satellites deployed in different orbits around earth from $2R_e$ to $10R_e$, and all the satellites are launched as a fleet and deployed in various orbit by the parent satellites.
- On orbit surveillance of bigger spacecraft functionality.
- Due to their reduced weight and volume, a small constellation of communication Nano satellites could be placed into orbit by a vast array of launch vehicles, quickly providing communications capability anywhere on the globe.

Student satellites have lot of potential in future and can give rise to lots of new developments in various technologies and are needed from strategic point of view also in near future. Keeping this in view, ISRO decided to support in design and launch of student satellites developed by Indian universities and other educational Institutions.

2 PARTICIPATION OPTIONS FOR UNIVERSITIES / INSTITUTIONS

Capable Universities and institution can venture into space technology on-orbit with guidance and support from ISRO in following ways.

2.1 Option-1: Development of Payload (by Universities/Institutions)

Every satellite carries a payload that performs the intended function to achieve the mission goal and the main bus that supports the payload function.

The Development of payloads may comprise of detectors, electronics and associated algorithms, which can be an experimental piggy back payload on the ISRO's on-going (Small or operational) satellite projects.

Design and development of detectors, payload electronics, and associated algorithm / experiments that enhance the application of space services to mankind is a continuing R&D activity in several educational institutions all over the world. Educational institutions can propose the payloads developed by them to be flown on ISRO's small satellites.

Under this option, payload only is developed by the Universities or Institutions and launched with ISROs satellite missions which has other ISRO's payloads. Data Handing and data transmission is done by ISRO as the part of satellite bus.

After launch ISRO will acquire payload data and disseminate it to Universities/ institutions further processing and analysis.

ISRO's responsibilities	Universities / Institutions responsibilities
1. ISRO will accommodate the payload in on-going missions along with other payloads. 2. Payload interfaces like power, TM-TC, Payload-BDH interface and mechanical interfaces. 3. Payload data will be received by ISRO and disseminated to corresponding university for data processing 4. Launch	1. Design & Development of Payload 2. Development of necessary test equipments. 3. Data processing procedures and algorithm developments. 4. Data product generation and study. 5. Data archival and dissemination among co-Institutions.

2.2 Option-2: Satellite Fabrication as per ISRO's Design.

Under this option, ISRO design of a standard Nano satellite bus will be provided to Institutions / universities. Universities / Institutions will have to fabricate and test the satellite bus. The payload will be designed, fabricated and tested by the Universities

Universities / Institutions are responsible for making and operating payload, Nano satellite and ground station.

After launch, the collected data will be archived and disseminated by University/Institution(s).

Under this option more than one University/Institution may participate. One among them will be the focal point for ISRO.

ISRO responsibilities	Universities / Institutions responsibilities
1. Providing Standard Nano satellite (INS) design with standard Mechanical and electrical interfaces. 2. Provide Critical materials like • Solar Cells (Panel) • Li ion Battery • Multi-Layer Insulation • Low emittance tape • Kapton Tape • Thermister 3. Design Reviews 4. Launch 5. Follow-up conference	1. Mission planning. 2. Payload design, development. 3. Satellite development. 4. Other necessary test equipment. 5. Establishing facilities. 6. Ground station development/lease from other Universities. 7. Data processing procedures and algorithm developments. 8. Procurement of all necessary components, materials, and test equipment. 9. Data product generation and study. 10. Data archival and dissemination among co-Institutions. 11. Operation and maintenance & contingency Management Payload mass limit : 1 Kg Max. power : 20 W Max. Size : 70x 70 x 50 mm^3

2.3 Option-3: Satellite Design & Fabrication by Universities/Institutions

Under this option Universities have to design, fabricate, test the satellite Bus & Payload and deliver the integrated spacecraft for launch. Technical guidance in designing, fabrication and testing will be provided by ISRO. Some critical materials for the space mission also will be provided by ISRO.

The designs and test results will be reviewed by ISRO team.

Under this option more than one University/Institution may participate. One among them will be the focal point for the ISRO. After launch, the collected data will be archived and disseminated by University/Institution(s).

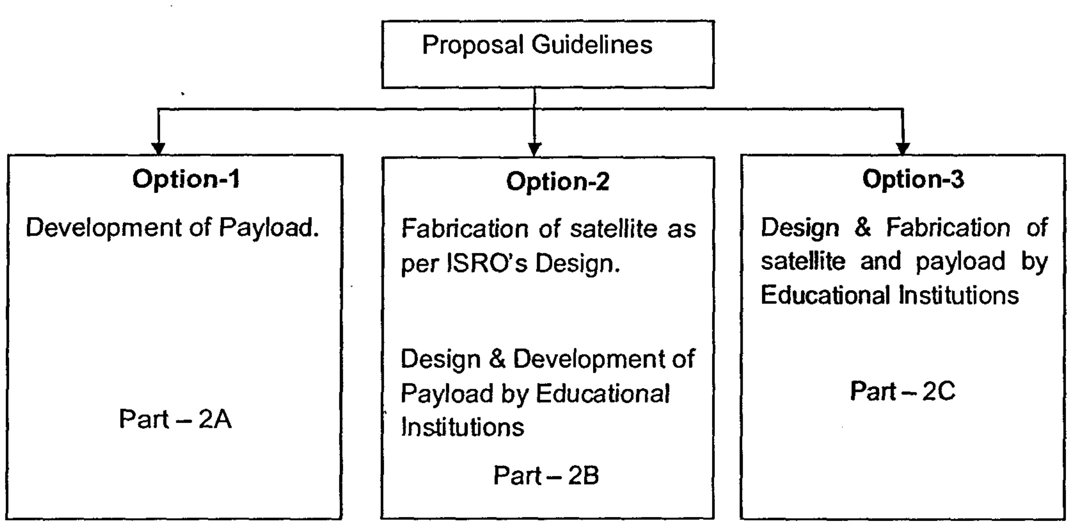
ISRO responsibility	Universities / Institutions responsibilities
1. Guidance in Design, Fabrication, Testing of payload, satellite bus, and ground segment. 2. Conducting design reviews 3. Providing critical materials like Solar Cells, Li ion Battery, Multi-Layer Insulation, Low emittance tape, Kapton Tape, Thermisters, 4. Launch 5. Follow-up conference	1. Satellite design and development 2. Payload design and development 3. Other necessary test equipment development 4. Establishing facilities 5. Ground station design/lease from other university 6. Delivery of satellite to launch 7. Data processing procedures and algorithm developments. 8. Procurement of all necessary components, materials, and test equipment. 9. Data product generation and study 10. Data archival and dissemination among co-Institutions. 11. Operation, maintenance and contingency management

2.4 Guidelines for proposal

In case of option-1 ISRO will design, fabricate, and test the satellites; however universities are responsible for developing payloads data processing systems, data utilization and associated systems. Part 2A of this document provides guidelines for the proposal.

In case of option-2 Universities/Institutions will fabricate, and test the satellites (based on the ISRO design); and will be responsible for developing payloads data processing systems, data utilization and associated systems. Part 2B covers this option

In case of option-3, satellite design, payload design, development, and testing will be done by universities / Institutions. Part 2C provides guidelines to proposal for this option.



Part-2A

Payload design and fabrication

by

Universities / Institutions

CONTENTS

1. INTRODUCTION

This part describes different topics and description to be covered in the payload proposal document.

The list of topics to be covered in the proposal document is provided in the following table 1.1. Each and every topic given in the table should be explained in detail in the proposal. Any other supporting topics also can be added.

The second chapter guides in preparing the proposal by providing typical write-ups.

Further chapters provide additional information to the Universities/Institutions to decide on various related factors.

Table 1.1 Proposal Format

S.NO	PROPOSAL FORMAT
1.	Introduction
2.	Mission 2.1 Mission objective 2.2 Mission specifications 2.3 Orbit and Attitude requirements
3.	Scientific aspects of Payload Payload Configuration Payload Specifications Electrical Configuration Mechanical Configuration Interfaces Technical feasibility Mission Planning
4.	Manpower & Organization (Project leader, system engineer, designers, etc)
5.	Project management plan
6.	Schedule
7.	Budget
8.	Users
9.	Data processing and usage plan

2. PROPOSAL DOCUMENT - TOPICS DESCRIPTION

2.1 Introduction

The introduction chapter of the proposal should include details of the University/ Institution which proposes the payload; importance of the proposed payload and its contribution to society.

2.2 Mission

The proposal to launch a payload through ISRO's satellite should provide the mission objectives clearly. The relevance of the objectives to the society and science also can be stated.

Points to be considered during the mission objective selection are

- Innovation in the project or technologies
- Financial support available,
- Facilities available at universities/ Institution
- Continuous manpower availability for project
- Commitment from Management, Faculty and Students

2.2.1 Typical mission objective

Typical mission objectives are as given below

- To design, develop and launch a Payload to observe/Monitor ....
- Using the payload data for the ....
- To gain experience in system engineering and team work

2.2.2 Typical Mission Specifications

Payloads can be for earth observation, atmospheric Monitoring, Ocean monitoring, stellar monitoring, electric, magnetic and gravitational field studies etc.

Typical Remote sensing mission specification

Spectral Bands :
    Band-1 :
    Band-2 :
Temporal resolution :
Radiometric Resolution :
Spatial resolution :
Pointing Specifications :

2.2.3 Orbit & Attitude Requirements

The orbit and attitude requirements should be provided in this section.

Altitude :
Inclination :
Local Time (If SSPO) :

Note: Orbit will be based on the main payload requirement. If the payload is orbit independent, the payload can have more launch opportunities.

2.3 Payload

2.3.1 Scientific aspects of Payload

This section should describe the science & technique used to meet the mission objective. The principles of operation and techniques of meeting goal,detector description and critical components required can be provided here.

2.3.2 Payload specifications

Mass :
Size :
Power :
Field of view :
Payload operation time/orbit :
Payload Look angle if any :
Data rate :
No. of Telemetry channels required (Digital and Analog) :
No. of Telecommand(s) required :
Mechanical & thermal interface requirement :
Any other specific requirement for the payload.

2.3.3 Payload configuration

Electrical configuration

Electrical system description, detailed block diagram(s) etc. are to be provided here.

Mechanical configuration

Mechanical configuration, thermal design, mechanism design (any deployments) if any can be given in this section.

Interfaces

Electrical Interfaces with power, Data handling system, telemetry, telecommand etc and mechanical interface like size, mass, temperature requirement are to be provided here.

Components

This section describes the components & materials (Bill of materials) are going to be used in the payload and their availability in Indian market. The list of components to be imported and the source country also to be provided.

2.4 Man power and organisation

This section should provide the team organisation, mix, members fields etc.

The team should comprise faculty, research scholars, system engineers and students. The system engineer, who has overall knowledge of payload from university / institutions, will be the in-charge for the payload project. He may be supported by faculty and research scholars from various relevant departments for the internal reviews and guidance.

Student coordinator, who has overall knowledge of the payload and in-depth knowledge of the sub system concerned, may be identified for interaction among various sub-systems and with ISRO.

The students from 2^{nd} year to 4^{th} year of all related disciplines will be included in the team which carryout design, fabrication and testing activities. This will enable the information flow/transfer from seniors to juniors. A typical organization is given in following Table 2-1.

The list of faculty, system engineer and students participating in the project is to be provided to ISRO with the proposal by name.

Table 2-1: Team Identification (suggested)

S.NO	SUB SYSTEMS	System Engineers	STUDENTS (approx.)	PROFESSORS/ASST. PROFESSORS
1.	**Detectors, Optics**	1	2	1
2.	**Mechanical System**	1	2	1
3.	**Electrical system**	1	4	1
4.	**Ground Segment**	1	4	1
5.	**R & QA**	1	4	1
6.	**Total**	5	16	5

2.4.1 Expertise availability

Pilot work conducted in the proposed payload/application may be provided in this section. List of publications if any, by the university can be included.

2.5 Project Managment Plan

The detailed project management plan consisting milestone activities including options should be made. Executive committee, different internal review boards, advisary boards, their heirarchy, frequency of their review etc. can be provided here. Configuration change control, tracking, information dessemination methods etc should be provided here.

2.6 Schedule

The estimated time required for the project is about 4 to 6 months before MOU and 15 to 20 months after MOU.

A typical schedule is given below. Addition to this table Gantt chart also can be used to represent the schedule.

	Events	Typical Time line (months)
1.	Submission of Payload proposal	T_0 - 4
2.	Project Approval	T_0 - 3
3.	Payload Configuration finalization	T_0 –2
4.	Submission of PDR documents	T_0 -1
5.	**Preliminary Design Review of Payload**	**T_0**
6.	MOU	T_0
7.	Engineering model readiness of payload	T_0 + 6
8.	**CDR for Payload**	**T_0 + 7**
9.	Flight model Payload readiness	T_0 +12
10.	Payload Bench level test & environmental tests	T_0 + 18
11.	**PSR of Payload**	**T_0 + 19**
12.	Handing over payload to ISRO	T_0 + 20

2.7 Budget and Fund Availability

Estimation of the funds required for this project and the list of fund providing channels may be given in this section. ISRO does not provide any financial assistance for developing the payload. Breakup of budget requirement is also to be provided in this chapter. Typical budget breaking is given below.

A Typical Budget allocation table is given below.

BUDGET SUMMARY			
		ALLOCATION [RS IN LAKHS]	
SL NO	ELEMENTS	TOTAL	FE
1	Project Elements	10.00	3.00
2	Program Elements	5.00	1.00
3	Customs duty	1.00	0.00
Total project cost		**16.00**	**4.00**

BUDGET SUMMARY – PROJECT ELEMENTS			
		ALLOCATION [RS IN LAKHS]	
SL NO	SUBSYSTEM	TOTAL	FE
1	Structure	3.00	1.00
2	Thermal	2.00	1.00
3	Electrical	2.00	1.00
4	Logistics	2.00	0.00
5	Administration	1.00	0.00
Project element cost		**10.00**	**3.00**

BUDGET SUMMARY – PROGRAM ELEMENTS			
		ALLOCATION [RS IN LAKHS]	
SL NO	SUBSYSTEM	TOTAL	FE
1	Computer hardware & software	2.00	0.00
2	Other Facilities	2.00	1.00
3	Payload data processing	1.00	0.00
Program element cost		**5.00**	**1.00**

Resources of Funds			
		Amount [RS IN LAKHS]	
SL NO	Source	TOTAL	FE
1			
2			
3			

2.8 Data Processing and Usage Plan

Plan of data processing, data analysis, data product generation, method of data dissemination to users and data utilisation plan shall be provided in this chapter.

2.9 Ground station design

The Data processing facility design in terms of hardware, software plan shall be provided in this chapter.

3. PAYLOAD REALISATION AND TESTING

This chapter provides realization and tests to be conducted on Payload.

The testing is based on the type of systems and way of system realization. The subsystems can be realized by two different ways

1. Buying space heritage payload from standard manufacturer
2. Developing payload by using components

If the payload or part of payload is bought, it should be tested for its performance. If the payload is new, designed and developed by university/institution, system development has to follow Bread Board Model (BBM), Engineering Model(EM) and Flight model(FM) philosophy.

Note: **ISRO encourages the indigenous design and development of systems.**

3.1 Electrical functional Test & Evaluation

The flight model payload should undergo full functional tests and full compliance to specifications under prescribed environmental conditions. T & E of payload is required for verification of design margins, weeding out parts / materials / workmanship defects in order to ensure successful operational use of payload. Test results at each stage should be documented.

The payload is to be tested with a suitable source simulator and the results may have to be used for comparison/calibration with data with in-orbit.

3.2 Environmental tests

To validate the performance of the payload under the simulated lift off and on orbit conditions. The complete payload with its electronics etc has to undergo the environmental tests to the specified level and durations as applicable for EM and FM. In addition to this payload level testing, full satellite also will undergo the environmental tests with the payload integrated.

3.2.1 Thermo vacuum test

This test is carried out to validate the performance of payloads under simulated adverse vacuum and temperature conditions. The purpose of this test is to uncover the deficiencies in parts, workmanship and system interface compatibility as well as the design (in Engineering model) under extreme conditions of temperature and vacuum a typical thermovac profile is given in Annexure-2.

3.2.2 Vibration Test

The typical vibration levels can be obtained after finalizing the payload to satellite interface. The payload should be designed and tested for vibration level which will be provided by ISRO.

4. FACILITIES REQUIRED AT UNIVERSITIES

4.1 Clean room

University should establish a clean room with following specifications to integrate, test and store the payload.

Class	: 100000
Area	: 100 s.qft (min)
Humidity	: 55$\pm$ 5%
Temperature	: 20±5°C

All ESD protection guidelines has to be followed.

4.2 Equipment required

Laboratory with the relevant fabrication, test equipments should be established /available near the clean room. The test equipment required for the proposed payload should be available at laboratory.

Typical list is

- Spectrum analyzer
- Oscilloscope
- Power meter
- Tool kit
- Power supply
- Multi-meter etc.

4.3 Work shop

University should have electrical and mechanical work shop for fabrication related activities (Soldering, PCB fabrication, Mechanical fabrication, and materials storage).

4.4 ESD protection tools

The typical ESD Protection tools are given below.

- Antistatic Coat
- Antistatic Mat
- Antistatic Flooring
- Antistatic Chairs
- Wrist bands

4.5 Ground Segment

The ground segment for data processing & data products generation should be established before the PSR of the payload. The ground segment consists of computer hardware, printers and software for process, analyse the data, display data in suitable format etc. The payload test data can be provided as input for the ground segment and get validated.

5. ISRO SUPPORT AND RESPONSIBILITIES OF UNIVERSITIES

ISRO will provide guidance, consultancy and support for design and developmental phase of Payload. The guidance is in the total systems engineering of the satellite. Consultancy in specific technology issues critical for the success of design of the sub-systems. ISRO also conducts identified periodic reviews and help the institution in the project management, if required.

5.1 ISRO's Responsibilities

- Providing thermal control material as given in the table 5.1
- Conducting reviews
- Integrated satellite test (ThermoVac, Vibration, Clean room)
- Accommodating the payload on Satellite

5.2 Components

The Institution/ Universities are responsible for all components procurement fabrication and functional test of the Payload. The list of items / components provided by ISRO is given below

Table 5.1 Materials support

S.No	Materials
1.	Multi-Layer Insulation blankets
2.	Low emittance tape
3.	Kapton Tape
4.	Thermistors
5.	Optical Solar Reflectors if required

5.3 Review

The development and test results will be reviewed by the Standing Review Committee appointed by the ISRO. Students have to participate in satellite level reviews also.

5.4 Facility

All the test equipments required during payload environmental tests are to be brought by Universities/Institutions.

5.5 Interactions

E-mails, phones and video conferencing may to be used extensively for communication / interactions.

Contact Details

Email: stu_sats@isac.gov.in.

Phone: 080-2508-2431/ 2508-2696 / 2508-2697

Postal Address:

The Programme Director, IRS & SSS
ISRO Satellite Centre
Vimanapura P.O
Bangalore – 560 017

Before reviews there may be visit of ISRO experts to universities / institutions. All logistics supports to be provided by universities.

5.6 Publicity and press related

Universities / Institutions should not publish the Payload project information (Technical &managerial) to any journal or news agencies without ISRO's written permission.

5.7 Security related issues

Satellite level reviews and environmental test will be conducted at ISRO. Nominally, following items are prohibited inside the ISRO campuses.

1. Laptops
2. Mobiles
3. Memory sticks
4. Camera
5. Calculators
6. Any electronic items

However, for presentation purposes one Memory stick / Laptop may be allowed if prior intimation is given.

6. REVIEWS

This section covers the reviews to be conducted during the design, development, test, pre-launch and post launch operations phases of the payload.

6.1 Introduction

Project implementation has various phases such as Study, Configuration definition, Design and Development, Qualification of the Engineering Model and fabrication & acceptance testing of Flight Model. On completion of each of these project phases, detailed reviews are held. The review team is chaired by an expert in related field and members of these review teams are drawn from various relevant disciplines. The reviews termed as Base Line Design Review, Preliminary Design Review, Critical Design Review and Pre-shipment review are conducted.

Reviews will be conducted at ISRO or at universities based on the requirements. As all experts and payload team members may not be able to attend the reviews in person, video conferences are preferable. The video conference facility at university end is desirable.

6.2 Baseline Design Review (BDR)

This is the conceptual Design review. Universities are to design the payloads and payload interfaces with the Satellite bus. This review includes trade-off study also.

The BDR marks the completion of the study phase. Inputs to the Baseline Design Review provided by the project team comprises of the following:

- Payload configuration, trade-offs and the configuration chosen.
- Power and Mass budgets, interface with spacecraft.
- Reliability apportionment
- Materials, components and process related issues regarding availability, qualification and reliability levels

The recommendations by the BDR Committee constitute the baseline of the configuration options and give the go-ahead for the development of breadboard models/ feasibility study models.

6.3 Preliminary Design Review (PDR)

This Review covers the Bread board model results. On satisfactory completion of PDR, the committee will recommend for MoU and it will be executed as per the time convenient to ISRO.

6.4 Critical Design Review (CDR)

The CDR covers the test results of the payload at various stages like bench level test, thermo-vacuum, vibration test etc. including earlier actions/closeout from PDR

The CDR is held after the qualification model of the payload has been subjected to various environmental tests and the test results are available. The recommendations by the CDR committee are on possible solutions to the problems and additional tests to be conducted, if required and giving the go-ahead for the realisation of the flight model.

6.5 Pre-Shipment Review(PSR)

This review is conducted before delivery of the payload to ISRO. This review covers the payload(FM) performance at bench level, vibration and thermo-vacuum tests.

The PSR committee reviews the following aspects: -

- Action close-out of the previous reviews.
- Payload test results of spare flight model if any. Problem analysis and corrective actions taken.
- Ground segment test results and readiness
- The PSR committee addresses the outstanding issues and recommends modifications to be carried out if necessary and provides the clearance for shipping the payload to ISRO.

6.6 Ground Segment Review

This review covers the readiness of Ground systems like payload data analysis and data production systems.

6.7 Visit of experts to University

Authorized members from ISRO will be visiting the Universities and its facilities at any time or stage of development with prior intimation.

7. RELIABILITY AND QUALITY ASSURANCE

Throughout the Payload design and realization product assurance ensures quality and reliability. Among the major components of product assurance are reliability engineering, parts, materials and process control program, test and evaluation, failure analysis, and non-conformance management. Milestone reviews such as the Preliminary Design Review (PDR) and Critical Design Review are conducted to ensure payload reliability.

7.1 Risk Management

Modularity

The payload design should be such a way that any sub-system card failed at any moment can be replaced with spare card, ie., system design should be with modular approach. Every card / system should have spare, identical to Flight Model. This approach will avoid delay due to sub-system failures.

7.2 Reliability Engineering

Reliability assessment will be carried out using data that include the subsystem block diagram, component list and component quality level, and the mission life by university / Institutions.

7.3 Parts Control

In general, **COTS (Commercial Off The Shelves)** components can be used.

The degassing material effect optical instruments of satellite. So the bill of materials should be provided to ISRO and get clearance before using them for fabrication.

7.4 Materials and Process Control

ISRO suggested materials should be used. The chosen materials should also meet the necessary magnetic cleanliness criteria. All materials will be subjected to incoming inspection.

All major processes such as PCB fabrication, electronic assembly, harness fabrication, etc. will be done by University/Institution or ISRO qualified vendors.

7.5 Test and evaluation

Functional and environmental tests will be conducted on payload after realization. These test are planned based on the payload and documented after considering individual test requirements.

7.6 Spacecraft-level Testing

Spacecraft level tests include functional tests, characterization and verification measurements, and environmental tests.

Integrated system tests (IST) will be conducted to verify spacecraft system functioning in disassembled and assembled conditions as well as after each environmental test. During the satellite test, the payload also will be tested. Student representative should be present during all the tests.

8. DOCUMENTS

Documents are the guides to the systematic development of any instrument. The documents are important instruments which pass the information within the development team, review team and from one semester students to next semester students. This chapter provides essential documents required to be prepared. The local body (experts) must review the results and documents before sending them to ISRO. Before coming to any review with ISRO experts, the detailed documents should be sent by mail minimum four working days prior to the meeting/reviews.

8.1 Project Proposal

The proposal document should contain the abstract, motivation and justification, system description, objective of the project, technical details like configuration; Interfaces etc. time schedule and budget information. Resources available/required to be identified

8.2 Design Documents

8.2.1 Baseline (Conceptual) Design Document

The baseline design document should contain

- payload configuration
- trade-offs and configuration chosen,
- restraints and demands on the spacecraft platform
- Block diagram, Power and Mass budgets
- Reliability apportionment
- Materials, components and process related issues regarding availability, qualification and reliability levels
- Software requirements

8.2.2 Preliminary Design Document

It should contain all the suggestions which are given in the Baseline design review. It should have the complete layout drawings, circuit diagrams, interface related information. Bread board model results to be included in this document.

8.2.3 Critical Design Document

This document is more detailed one and should contain all the test results of qualification model Payload for ISRO experts to review more critically. The PDR Recommendations and implementations should be included in this document.

8.2.4 Pre-Shipment Review Document

This is the final review which takes place based on the test results provided by payload team. All reviews recommendations and implementations should be included in this document.

8.3 Interface Documents

- Electrical interface document, Mechanical interface document
- Ground segment interface (Data format etc.)

8.4 Data product Document

- Payload data processing and quality analysis document.

8.5 On-Orbit Performance Report

This Document/Report is to be provided by the university to ISRO every month after launch.

9. FABRICATION GUIDELINES

The idea behind student's involvement in space activities is to build payload by universities taking advantage of commercially available off-the-shelf components. The procedures for fabrication, on the other hand, will be those that are prescribed by ISRO and the system including the printed circuit boards (PCBs) and the associated soldering in of components will be done at Universities or at ISRO suggested facilities and will conform to ISRO approved standards. The testing of the each sub-system comprises multiple levels.

Universities / Institutions are responsible for fabricating payload structure and PCBs.

ISRO Satellite Centre has identified Industries for the spacecraft activities like Electrical Fabrication, Mechanical Elements Fabrication, Assembly of Packages and tests etc. The Universities may select any one of the fabricator for spacecraft work.

9.1 Electrical

The PCB Design Guidelines can be obtained from the ISAC generated document Name "COMPILATION OF FOOTPRINT DESIGNS OF COMPONENTS USED IN ONBOARD PCB LAYOUTS" With Reference No. ISRO-ISAC- ST-0125.

9.2 Thermal

With the actual power dissipations of the payload, thermal simulations need to be performed taking the orbit and attitude profiles, operation times, sun angle variations, etc. Passive control elements to be used for the thermal design as the power generated will be very less. Thermal simulations should demonstrate the thermal margins for all the critical systems considering the on orbit mission scenario.

9.3 Mechanical

The mechanical elements can be fabricated by Universities/Institutions as per ISRO standards.

10. CHECKLISTS

The following table(Table.10.1) will be referred before recommending to MOU. This table will be filled by Programme Management Office IRS & SSS Table 10-1: Check list for MOU

Sl.No	Check list for MOU	Marks	Weight age	score
1	Mission goal			
2.	Orbit requirement			
3.	Project Team formation			
4	Configuration options selected			
5	Design margins			
6	Facilities available			
7	Capacity to spend the amount mentioned			
8	Technical Capability			
9	Conceptual Design Review			
10	Preliminary Design Review			
11	Ground Segment Plan			
12	Commitment to post launch activities			
13	Imported Item Percentage in design			
14	Other Institutions Participation			
15	Data utilization Plan			

Following tables will be referred before integrating the payload with satellite.

Table 10-2: Checklist of Reviews

Sl.No	Reviews	Date	Reviews by	Actions Closed	Closeout Note
1.	Baseline design (BDR)			□	□
2.	Preliminary design (PDR)			□	□
3.	Critical design (CDR)			□	□
4.	Ground segment design(GDR)			□	□
5.	Ground segment test results			□	□
6.	Data utilization plan			□	□

Table 10-3: Checklist of Documents

Sl.No	Documents	Date	Time line	Done
1.	Baseline design documents		BDR	□
2.	Preliminary design documents		PDR	□
3.	Critical design documents		CDR	□
4.	Mission readiness documents		MRR	□
5.	Ground segment design document		PDR	□
6.	Ground segment test results document		CDR	□
7.	Data utilization plan document		MRR	□

Table 10-4: Checklist of Test & Evaluation

Sl.No	Test & Evaluation	Date	Results Document	observations	Done
1.	Bread board model T&E		☐		☐
2.	Bench level		☐		☐
3.	Engineering model		☐		☐
4.	Flight model		☐		☐
5.	Ground segment Test		☐		☐
6.	Thermo vacuum test		☐		☐
7.	Vibration test		☐		☐

Table 10-5: Checklist of Clearances

Sl.No	Clearances	Date	Done
1.	Accommodation clearance with satellite		☐
2.	Material Clearance (Degassing etc)		☐
3.	All committees clearance		☐

Part-2B

Satellite fabrication as per ISRO's design

CONTENTS

1. INTRODUCTION

This part describes different topics and description to be covered in the satellite proposal document. The tests to be conducted, documents to be generated during the satellite development are outlined in this guide book.

The list of topics to be covered in the proposal document is provided in table.1.1 Each and every topic given in the table should be explained in detail in the proposal. Any other supporting topics also can be added.

The second chapter explains the information to be provided under each topic of the proposal.

Further chapters provide additional information to the universities/Institutions to decide on various related factors.

Table 1.1-FORMAT for student satellite proposal

S.NO	PROPOSAL FORMAT
1.	Introduction
2.	Mission 2.1 Mission Objective 2.2 Mission specifications 2.3 Payload selection 2.4 Orbit Selection
3.	Scientific aspects of Payload Payload Configuration Payload Specifications Electrical Configuration Mechanical Configuration Interfaces
4.	Manpower & Organization (Project leader, designers, etc)
5.	Project Management Plan
6.	Schedule
7.	Internal review mechanism (Members list)
8.	Budget
9.	Users
10.	Data processing and usage plan
11.	Data dissemination plan to users
12.	Ground Segment Design

2. PROPOSAL DOCUMENT - TOPICS DESCRIPTION

2.1 Introduction

The introduction chapter of the proposal should cover about the University/ Institution which proposes the satellite. Importance of the proposed payload and its contribution to the society can be explained here.

2.2 Mission

The proposal to launch a payload on INS(ISRO Student satellite Bus) bus should provide the mission objectives clearly.

Points to be considered during the mission objective selection are provided in this chapter. Some important points to be considered are

- Innovation in the payload design
- Capability of INS Bus (design will be provided by ISRO)
- Financial support available,
- Facilities available at universities
- Continuous manpower availability for project
- Commitment from Management, Faculty and Students

2.2.1 Mission objective

The Mission objective should reflect the motive of this mission and any spin-off utilization due to it etc

The mission objective format is as given below

- To design, develop a Payload to observe ....
- Fabricating , testing, interfacing payload with INS bus
- Using the payload data for estimating ....
- Using the payload data for study the frequency of occurrence of ....

Typical Mission Objective (Example) is

- To observe the forest for their density, type of trees, area variation due to season, area variation due to infrastructure development
- To Gain experience in designing a multispectral space qualified camera
- To gain experience in system engineering and team work

2.2.2 Mission specification

The mission specifications are derived from the mission objective. It has to give the scientific concept utilized in the payload and its suitability for the mission objective.

The Typical mission specifications are as follows

The spectral band :

Look angle :

SNR of the Instrument :
Orbit, Altitude :
Local Time (SSPO) :

Example

No. of Spectral Band required :2
Band -1 : 0.62-0.68 micron
Band-2 : 0.77-0.86 micron.
Resolution : 50 m
Swath : 300 Km

(Reason for selection of these values to be explained)

2.2.3 Payload specification

This section provides a typical payload specification to meet the Mission Specification.

Example

No. of Spectral Band required :2
Focal length : 200 mm
FOV : +/-12 deg.
Detector : 4096 element CCD

2.2.4 Orbit selection

All Student satellites will be launched as piggy back with main satellites. The orbit selection will be based on main satellite requirement. Preferably these Student satellites mission should be orbit independent.

- If payload choice for Student satellite is orbit specific, the launch opportunities will be limited.
- If it is polar sun synchronous orbit launch opportunity is better.

A typical format is given below

Orbit Type	:	Polar / Low inclination
Local time	:	10.00 AM
Altitude	:	(above 500 Kms)
Inclination	:	98 deg.
Design Life	:	>1Year

2.3 Payload

2.3.1 Scientific aspects

This section should describe the science, techniques used to meet the mission objective.

2.3.2 Payload configuration

This section should describe the design of the payload. It should present a generic specification concerning the mechanical, thermal, electrical design and interfaces between the satellite bus and the payload.

In the case of the Option-1 this section has to provide following information also.

Size of payload	:
Power	:
Mass	:
Look Angle	:
TM/TC Requirement	:
Payload Data rate	:
Operation Time per Orbit	:
Type of interface for TM/TC	:
Type of interface for Payload	:
Any other parameters	:

2.4 Man power and organisation

The student satellite team organization chart and table are to be provided in this chapter.

The Satellite team should comprise System Engineer, faculty, research scholars and students. The system engineer, who has over all knowledge of satellite systems from university / Institutions will be the in-charge for student satellite development. He may be supported by faculty and research engineers from various relevant departments for the internal reviews and guidance.

Student coordinator, who will have overall knowledge of the spacecraft and in-depth knowledge of the system concerned, is to be identified for interaction among various sub-systems and with ISRO. The list of faculty, system engineer and student coordinators are to be provided to ISRO with the proposal by name.

The students from 2nd year to 4th year of all related disciplines will be included in the team which carryout design, fabrication and testing activities. The structure of typical team is as given below.

Sufficient students are required for fabrication, system engineering, and testing for the INS bus and design, development, fabrication, testing of payload and ground segment

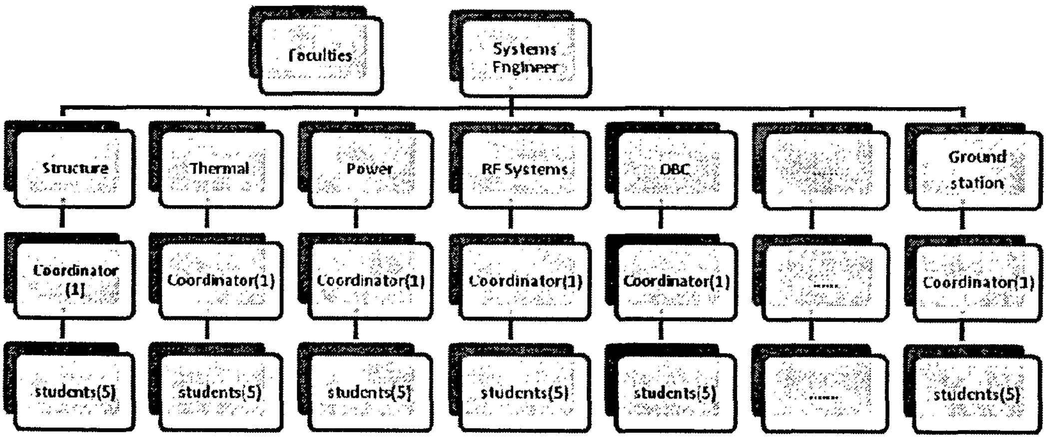


Figure 2-2 Different Disciplines & students participation

Table 2-1: Team Identification (suggested)

S.NO	SUB SYSTEMS	STUDENT Coordinator	STUDENTS (approx.)	PROFESSORS/ASST. PROFESSORS
1.	System Engineer	1	2	1
2.	Structure	1	4	1
3.	Thermal	1	4	
4.	Power system	1	4	1
5.	RF System	1	4	
6.	On board computer	1	4	1
7.	On Board Software	1	4	
8.	ACS	1	4	1
9.	Sensors	1	4	
10.	Actuators (RW)	1	4	
11.	Ground Segment	1	4	1
12.	Payload	1	4	1
13.	R & QA	1	4	-
14.	Total	13	50	7

2.5 Project management plan

The detailed project management plan consisting executive committee, advisary boards, their heirarchy, frequency of their review etc. can be provided here. Configuration change control, tracking, information dessemination methods etc should be provided here. Milestone activities like completion of major activities, reviews can also be visited.

2.6 Schedule

The Schedule is to be provided in this chapter in table form as exmaple given below. Addition to this table the schdule can be presented in Gantt chart form also.

Typical Schedule chart is provided below

	Events	Time line (months)
1.	Submission student satellite proposal	T_0 - 4
2.	Project Approval	T_0 - 3
3.	S/C Mainframe Configuration finalization	T_0 - 2
4.	Submission of PDR documents	T_0 -1
5.	Preliminary Design Review of Payload and G/S	T_0
6.	MOU	T_0
7.	Applying for frequency clearance	T_0
8.	Engineering model of payload	T_0 + 6
9.	CDR for Payload and Ground segment	T_0 + 6
10.	Flight model Spacecraft readiness	T_0 +18
11.	Availability of frequency clearance certificate	T_0 +18
12.	Payload Readiness	T_0 + 18
13.	Integrated S/C readiness	T_0 + 20
14.	S/C IST& environmental tests	T_0 + 23
15.	Readiness of Ground segment	T_0 + 23
16.	**PSR of S/C**	**T_0 + 23**
17.	Handing over satellite to PSLV at launch site	T_0 + 24

Note: On satisfied completion of PDR, the committee will recommend for MoU and it will be executed as per the time convenient to Department Of Space.

2.7 Internal review mechanism

Internal technical review committees list and review mechanism is to be presented here.

2.8 Budget

The studentsatellite fabrication and testing may cost ~ 1 Crore as on today. Money allocation for various activities can be provided here in table form.

Typical budget allocation table is given below.

Budget summary			
		Allocation [Rs in lakhs]	
Sl no	**Elements**	**Total**	**FE**
1	Project elements	40.00	23.00
2	Program elements	25.00	10.00
3	Custom duty	10.00	0.00
Total project cost		**75.00**	**33.00**

(FE – Foreign Exchange content)

Budget summary – project elements			
		Allocation [Rs in lakhs]	
Sl No	Subsystem	Total	FE
1	Structure	2.00	0.00
2	Thermal	1.00	0.00
3	Mechanisms	1.00	0.00
4	RF systems	1.00	1.00
5	OBC	2.00	2.00
6	Power system	1.00	2.00
8	Sensor systems	1.00	1.00
9	Integration system	1.00	2.00
10	R & QA	1.00	0.00
11	Mission planning	2.00	0.00
12	ETF/EFF/MFF	2.00	5.00
13	Payload	5.00	10.00
14	Logistic	10.00	0.00
15	Administration	10.00	0.00
Project element total		**40.00**	**23.00**

Budget summary – program elements			
		Allocation [Rs in lakhs]	
Sl No	Subsystem	Total	FE
1	Ground elements	10.00	5.00
2	Facilities	10.00	5.00
3	Payload data processing	5.00	0.00
Program elements total		**25.00**	**10.00**

2.9 Users

If there is a plan to share the payload data among other universities and colleges, a list of users can be provided here. More number of users participation is preferrable and encouraged.

2.10 Data Processing and Usage Plan

Plan of data processing, Data analysis, Data product generation, method of Data dissemination to users and data utilisation plan shall be provided here.

2.11 Ground station design

Satellite control system design which consists of transmitter (TC) receiver(TM), antenna, process hardware, software are to be discussed here.

The payload data reception centre design, Data processing facility design in terms of hardware, software plan can be provided here.

3. SPACECRAFT TESTING

This chapter provides various tests to be conducted on satellite.

The testing is based on the type of systems and way of system realization. The subsystems can be realized by two different ways

1. Buying space heritage systems from standard manufacturer
2. Developing by using COTS components

If the subsystem is bought, it will be tested for its performance and integrated with satellite.

If the subsystem is designed and developed by universities, system development has to follow breadboard model, engineering model and Flight model. Since INS Design is proven one, the BBM and EM are not required. Payload development has to follow BBM,EM and FM models.

ISRO encourages indigenous design and development of systems.

3.1 Electrical test and evaluation

Each flight model subsystem should undergo full functional tests and full compliance to system specifications under prescribed environmental conditions. T & E of each subsystem is required for verification of design margins, weeding out parts / materials / workmanship defects in order to ensure successful operational use of integrated spacecraft. Test results at each stage should be documented.

3.2 OILS Test

Complete integration of ADCS(Attitude Determination and Control System) components like OBC, sensors, IRU, RWs undergo in loop dynamic simulations before certifying the subsystems for integrating with S/C.

3.3 Integrated Spacecraft test (IST)

3.3.1 Dis assembled and Assembled mode IST

- End to end checks for each subsystem before and after spacecraft integration.
- Polarity checks for sensors.
- All subsystems functional and performance test in clean room environment in integrated condition.
- Battery emergency checks,
- All sub-systems interface compatibility checks.
- Ground station compatibility test with FM

3.4 Environmental tests

To validate the performance of the integrated spacecraft under the simulated lift off and on orbit conditions.

3.4.1 Thermo vacuum test

Carried out to validate the performance of all the on board sub systems under simulated adverse vacuum and temperature conditions. This test uncovers the deficiencies in parts, workmanship and intra system interface compatibility under extreme conditions of temperature and vacuum.

3.4.2 Vibration Test

The typical vibration levels of PSLV launch vehicle is provided below. The student satellites should be designed and tested for these values. Vibration levels will be provided in INS Kit user manual

3.5 Ground segment compatibility test

Prior to commencement of pre-launch simulation, test and evaluation of entire ground segment should be carried out. Functional compatibility checking of ground stations with the satellite should be carried out successfully and test results to be documented & presented to the PSR committee.

3.6 Pre-Launch phase test & activities

Prior to handing over satellite to PSLV team, the following activities / test should be carried out.

- End to end checks
- Battery charging
- Final thermal work
- Removal of all non-flight components

4. FACILITIES REQUIRED AT UNIVERSITIES

4.1 Clean room

University should establish a clean room with following specifications to integrate, test and store the spacecraft.

Class	:	100000,
Area	:	200 sqft ,
Humidity	:	55 ±5 %
Temperature	:	20±5°C

All ESD protection guidelines has to be followed for establishing clean room

4.2 Laboratory & Components stores

University should establish a Laboratory& Components stores with following specifications to perform bench tests, to store procured components / modules / sub-systems.

Area	:	200 sqft
Temperature	:	20±5°C

4.2.1 Equipments required

Laboratory must have following equipment / tools

- Spectrum analyzer
- Oscilloscope
- Power meter
- Tool kit
- Power supply
- Multi-meter etc.

4.2.2 Work shop

University should establish electrical and mechanical work shop for fabrication related activities (soldering, PCB fabrication, Mechanical fabrication, and materials storage).

4.2.3 Hot and cold / thermo vacuum chambers

Preferably, universities may establish hot and cold / thermovacuum chamber. However ISRO facilities can be used for Engineering and Flight Model testing with advance request and permission.

4.2.4 Vibration lab

Preferably, universities may establish vibration lab. However ISRO facilities can be used for Engineering and Flight Model testing with advance request and permission.

4.2.5 ESD protection tools

The ESD protection tools are given below that needs to be used for FM assembly and during tests/integration etc.

- Antistatic Coat
- Antistatic Mat
- Antistatic Flooring
- Antistatic Chairs
- Wrist bands

4.2.6 Ground station

Ground Station should have the following features:

- Command transmission and P/L data and telemetry reception
- Tracking of the satellite
- Data acquisition and storing
- Display of satellite position
- Display of health monitoring and performance of the satellite
- Maintenance and support
- Data processing and usage
- Data dissemination plan to users

Health data processing software should process the spacecraft telemetry data and display spacecraft health in both real time & playback modes and ensure the system performance.

Utility software should support following utilities.

1. Selected parameter print out,
2. Master frame print out,
3. Real time graphics on terminal and
4. Near-real time graphics plotting.

Archival software should take care of merging real time & playback data and store for future use.

Ground station compatibility test must be demonstrated with engineering model and live satellites to ensure the ground station readiness.

5. ISRO SUPPORT & UNIVERSITIES RESPONSIBILITIIES

ISRO will provide guidance, consultancy and support during developmental phase of educational satellites. The guidance is in the total systems engineering of the satellite.. ISRO also conducts identified periodic reviews and help the institution in the project management, if required.

5.1 ISRO's Responsibilities

- Providing the materials as given below
- Conducting reviews
- Integrated satellite test support (ThermoVac, Vibration, Clean room)
- Launching the satellite

5.2 Components

The Institution/ Universities are responsible for all components procurement fabrication and functional test of the spacecraft. The list of items / components provided by ISRO is given below

Table 5-1: Materials support

S.No	Materials
1	Solar Cells
2	Li ion Battery
3	Multi-Layer Insulation
4	Low emittance tape
5	Kapton Tape
6	Thermistors
7	Optical Solar Reflector

5.3 Review

The development and test results will be reviewed by the Standing Review Committee appointed by ISRO.

5.4 Facility

All the test equipments required during environmental tests are to be brought by University/Institutions

5.5 Interactions

E-mails and phones may to be used extensively for communication / interactions.

<u>**Contact Details**</u>

Email : stu_sats@isac.gov.in.

Phone : 080-2508-2431/ 2508-2696 / 2508-2697

Postal Address

The Programme Director, IRS & SSS
ISRO Satellite Centre
Vimanapura P.O
Bangalore – 560 017

Before reviews there may be visit of ISRO exports to universities / institutions. All logistics supports to be provided by universities.

5.6 Publicity and press related

Universities / Institutions shall not publish the Student satellite project information (Technical & managerial) to any journal or news agencies without ISRO's written permission.

5.7 Security related issues

Important reviews will be conducted at ISRO. Nominally, following items are prohibited inside the ISRO campuses.

1. Laptops
2. Mobiles
3. Memory sticks
4. Camera
5. Calculators
6. Any electronic items

However, for presentation purpose one Memory stick / Laptop may be allowed if prior intimation is given.

5.8 Frequency Clearance

Frequency clearance is the responsibility of the universities/Institutions. Since educational satellites are basically designed and developed by Universities, the frequency clearance is to be taken by the respective University or Institution. For all educational satellites, it is recommended to operate in antenna frequency bands called HAM band. The University/Institution needs to register the chosen frequencies in UHF and VHF bands with IARU(International Amateur Radio Union)

6. REVIEWS

6.1 Introduction

Project implementation has various phases such as Study Phase, Spacecraft Configuration Definition, Design and Development of sub-systems, Qualification of the Engineering Model and the fabrication and Acceptance Testing of the Flight Model. On completion of each of these project phases, detailed reviews are held. The review team is chaired by an expert in spacecraft technology who is not directly connected with the project. The members of these review teams are drawn from various specialised disciplines. The reviews termed as the Base Line Design Review, the Preliminary Design Review, the Detailed Design Review, the Critical Design Review, the Pre-shipment and Flight Readiness Review are conducted.

Reviews will be conducted at ISRO or at universities based on the requirements. As all experts and student satellite members may not be able to attend the reviews in person, video conferences are preferable. The video conference facility at University end is desirable and helpful in reviews and discussions.

6.2 Baseline Design Review (BDR)

This is the conceptual Design review. As the bus design is provided by the ISRO. Universities are to design the payloads and payload interfaces with the Satellite Bus. This review includes the trade-off study also.

The BDR marks the completion of the study phase. Inputs to the Base Line Design Review provided by the project team comprises of the following:

- Payload and mainframe subsystems configuration trade-offs and the configuration chosen. Restraints and demands on spacecraft platform.
- Power and Mass budgets as well as spacecraft interfaces.
- Software Design requirements
- Reliability apportionment
- Materials, components and process related issues regarding availability, qualification and reliability levels
- Complete requirements at subsystem and system level

The recommendations by the BDR Committee constitute the baseline of the configuration options and give the go-ahead for the development of breadboard models/ feasibility models.

6.3 Preliminary Design Review (PDR)

This Review covers the Bread board model results of various subsystems. The tests will be conducted as individual system. On satisfied completion of PDR, the committee will recommend for MoU and it will be executed as per the time convenient to Department Of Space.

This review is held after the breadboard model activity of the new subsystems is completed and a preliminary design is made available to the project. Recommendations of the PDR committee include configuration/design modifications required in order to meet the specifications and verification of adequacy of the quality of the components

6.4 Critical Design Review(CDR)

The CDR covers the test results of the sub systems at various stages like bench level test, thermo-vacuum, vibration test.

The CDR is held after the qualification model of the satellite /subsystems has been subjected to various environmental tests and the test results are available. The recommendations by the CDR committee are on possible solutions to the problems and additional tests to be conducted, if required and giving the go-ahead for the realisation of the flight model.

6.5 Pre-Shipment Review(PSR)

This review will be conducted before the movement of the satellite to the launch pad. This review covers the satellite performance in assembled mode, Vibration test and thermo-vacuum test.

The PSR committee reviews the following aspects: -

- Action close-out of the previous review

Detailed flight spacecraft level test results, problems faced and corrective actions taken and the outstanding deviations and their mission Impact

- Subsystem test results of spare flight model. Problem analysis and corrective actions taken.
- Ground segment readiness
- The PSR committee addresses the outstanding issues and recommends modifications to be carried out if necessary and provides the clearance for shipping the spacecraft to the launch base.

6.6 Mission Review

This Review covers the readiness of Satellite and Ground systems like TTC and Payload data reception systems.

6.7 Work Based Reviews

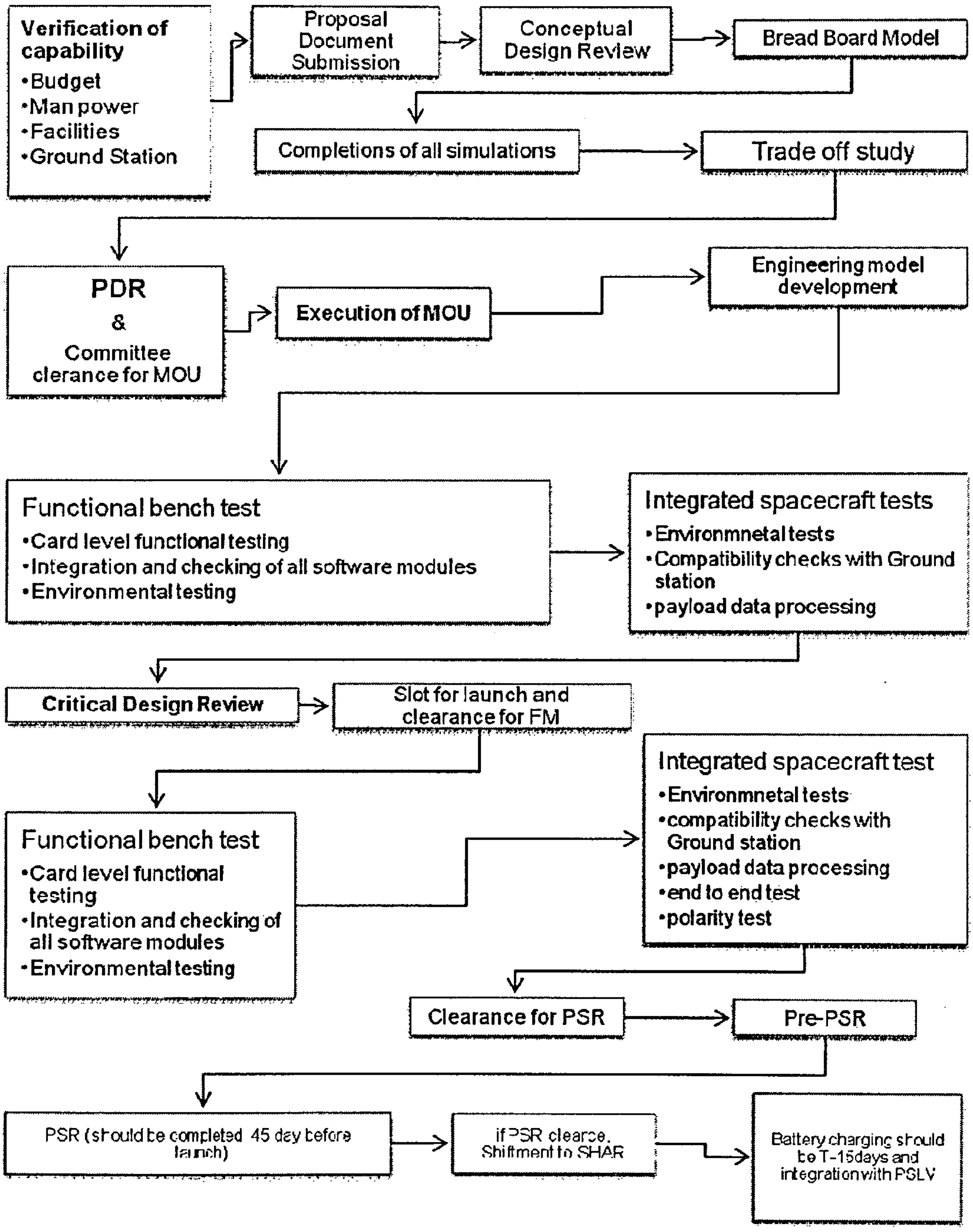
6.7.1 Test Results Review

These reviews are conducted when the tests are completed at each stage.

6.7.2 Failure Analysis Review

These reviews will be conducted when some component failed. The fabrication /test/ storage conditions are reviewed.

6.8 Realization steps of student satellite project



7. RELIABILITY AND QUALITY ASSURANCE

Throughout the spacecraft design and realization product assurance ensures quality and reliability. Among the major components of product assurance are reliability engineering, parts, materials and process control program, test and evaluation, failure analysis, and non-conformance management. Milestone reviews such as the Preliminary Design Review (PDR) and Critical Design Review are conducted to ensure spacecraft reliability.

7.1 Risk Management

The spacecraft design should be modular in such a way that any sub-system card failed at any moment can be replaced with spare card, ie., system design should be with modular approach. Every card / system should have spare, identical to Flight Model. This approach will avoid delay due to sub-system failures.

7.2 Testability

The spacecraft design should support testing any sub-system without disassembling the satellite.

7.3 Reliability Engineering

Reliability assessment will be carried out using data that include the subsystem block diagram, component list and component quality level, and the mission life by university / Institutions.

7.4 Parts Control

In general, **COTS (Commercial Off The Shelves)** components will be used. The degassing material will affect optical instruments of the Student satellite and main satellite. So the bill of materials should be provided to ISRO and clearance obtained , before using them for fabrication.

7.5 Materials and Process Control

ISRO suggested materials will be used. The chosen materials will also meet the necessary magnetic cleanliness criteria. All materials will be subjected to incoming inspection.

All major processes such as PCB fabrication, electronic assembly, harness fabrication, etc. shall be done by ISRO qualified vendors.

7.6 Test and evaluation

Functional and environmental tests will be conducted on equipment after realization. These tests are designed and documented after considering individual test requirements. New designs, depending upon the degree of modification from an existing design, may either have a qualification model or will be subjected to proto-flight testing. For purchased units, the appropriate test philosophy will be incorporated in the purchase specifications. Each of the subsystem units will be subjected to the expected EMI, thermal and vacuum, and dynamic environments, as per the environmental test specifications document.

7.7 Spacecraft-level Testing

Spacecraft level tests include functional tests, characterization and verification measurements, and environmental tests.

Integrated system tests (IST) will be conducted to verify spacecraft system functioning in disassembled and assembled conditions as well as after each environmental test. EMI/EMC test will be conducted to clear electro-magnetic interference concerns. The spacecraft will undergo a thermal-vacuum test to verify system performance in space temperature and vacuum environment. Other environmental tests are sine and random (or acoustic) vibration tests, and shock test, if called for.

Measurement of physical properties such as mass, position of the spacecraft center of gravity, and spacecraft moment of inertia will be carried out after complete integration of spacecraft. Spacecraft imbalance measurement and correction also will be conducted in completed spacecraft configuration. Sensors alignment measurement and correction, wherever necessary, also will be conducted prior to and after the dynamic tests. Launcher interface verification to ensure trouble-free integration of spacecraft to the launcher also will be conducted at an appropriate phase of spacecraft integration. Quality assurance also ensures health and suitability verification of electrical and mechanical ground support equipment (EGSE and MGSE). Major EGSE includes checkout computers, power supplies, battery and solar panel simulators, and uplink/downlink equipment. MGSE comprises integration fixtures and handling systems for equipment and spacecraft as well as transportation containers.

7.8 Transportation and Launch Base Product Assurance

Quality assurance also oversees with Integration, packing and transportation of spacecraft to launch location. After the receiving inspection by Quality Assurance, launch base operations begin which involves launch base IST, deployments, if necessary, and alignment verification. Quality assurance will carry out surveillance during these operations.

7.9 Configuration Management and Document Control

Subsystem and spacecraft configuration management and control will be implemented with focal points identified from the subsystem groups, Quality Assurance and the Project Management group. Drawing and document revisions will be controlled with a mechanism to annul older versions and to disseminate the most recent versions to all project executives.

8. DOCUMENTS

Documents are the guides to the systematic development of systems. Documents are important instruments which pass the information within the development team and from one semester students to next semester students. This chapter provides minimum number of documents required to be prepared.

8.1 Project Proposal

The proposal document should contain the Abstract, Motivation and justification, System description, objective of the project both technical and service, time line, budget related and kind of support expecting from ISRO. The project proposal should also contain its goal, launch, mission management, orbit, life reliability.

It is essential that there should be a strong commitment by the Institution for the student satellite project. For a successful completion of the project strong and sustained commitment is essential from management, faculty and students. The project being primarily student driven, support of faculty from various departments is required. Before coming to ISRO for any review the local body must review and also few faculty members should also accompany the students and the detailed documents should be sent by mail four working days prior to the meeting.

8.2 Design Documents

8.2.1 Baseline (Conceptual) Design Document

- The project team can be asked to come with a conceptual design review at ISRO premises for evaluation of their Project on specified dates.
- The detailed proposal sent by the Institution needs to be evaluated and graded for acceptance, conduct a preliminary conceptual design review.
- The Standing Review Committee (SRC) identified for the Student satellite will review the proposal and also review the presentations and provide recommendations to the Apex Committee.

8.2.2 Preliminary Design Document

It should contain all the suggestions which are given in the Base line design review. It should have the complete layout drawings, circuit diagrams, interface related, formats, commanding information with codes, RF link margins, communication protocols.

8.2.3 Critical Design Document

This document is more detailed one and should contain all the test results of sub-systems for ISRO experts to review more critically.

8.2.4 Pre-Shipment Review Document

This is the final review where the total satellite will take place based on the test results provided by individual sub-committee chairmen. The shipment of the satellite for launch will depend on the PSR recommendation.

8.3 Interface Documents

- Subsystem Interface definition document
- Electrical Interface document, Mechanical interface document
- Launch Vehicle Interface
- Ground Segment Interface (Data format etc.)
- Software Interface control document
- Thermal Interface control document

8.4 Mission operation document

- Mission operation/Sequence of Operation (SOE) document
- Launch phase operation document
- Contingency recovery procedure document
- Payload data processing and quality analysis document.

9. FABRICATION GUIDELINES

The advantage of a student satellite built by universities is using commercially available off-the-shelf components. In keeping with this practice, the components used for the spacecraft can be those that have been used regularly by students- no special space grade components need to be used. The practices for fabrication, on the other hand, will be those that are prescribed by ISRO and the system – including the printed circuit boards (PCBs) and the associated soldering in of components will be done at ISRO suggested facilities and will confirm to ISRO approved standards. The testing of the each sub-system comprises of multiple levels.

The software and hardware of each interface shall be tested individually with the associated components from the other sub-systems. This is followed by the testing of the entire information pathway which links the power, on-board computer and communication sub-systems. This will be followed by On-board computer In Loop.

Universities / Institutions are responsible for all fabrication including structure and PCBs.

ISRO Satellite Centre has identified Industries for the spacecraft activities like Electrical Fabrication, Mechanical Elements Fabrication, Assembly of Packages and test etc. The Universities can select any one of the fabricator for spacecraft work.

9.1 Electrical

The PCB Design Guidelines can be obtained from the ISAC generated document Name "COMPILATION OF FOOTPRINT DESIGNS OF COMPONENTS USED IN ONBOARD PCB LAYOUTS" With Reference No. ISRO-ISAC- ST-0125. Electrical systems can be fabricated by Universities/ Institutions as per ISROs standards or through ISRO Qualified Vendors.

9.2 Thermal

With the actual power dissipations for the satellite, thermal analysis need to be performed taking the orbit and attitude profiles, operation guides, sun angle variations and enough margins are to be demonstrated for all the critical systems. The materials used, mechanical points needs to be simulated as close as possible to the realistic satellite. Passive control elements are to be used for the thermal design as the power generated will be very less. Thermal simulations should demonstrate the thermal margins for all the critical systems considering the on orbit mission scenario.

9.3 Mechanical

The mechanical elements can be fabricated by Universities/Institutions as per ISRO standards.

10. CHECKLISTS

The following table will be referred before recommending to MOU. This table will be filled by Programme Management Office IRS & SSS

Table 10-1: Check list for MOU

Sl.No	Check list for MOU	Marks	Weight	Score
1	Mission goals			
2.	Orbit requirement			
3.	Project Team formation			
4	Configuration options selected			
5	Design margins			
6	Facilities available			
7	Capacity to spend the amount mentioned			
8	Technical Capability			
9	Conceptual Design Review			
10	Preliminary Design Review			
11	Ground Segment Plan			
12	Commitment to post launch activities			
13	Imported Item Percentage in design			
14	Other Institutions Participation			
15	Data utilization Plan			

Following tables will be referred before clearing for Shipment of Satellite to launch pad

Table 10-2: Checklist of Reviews

S.No	Reviews	Date	Reviews by	Actions Closed	Closeout Note
1.	Baseline design (BDR)			□	□
2.	Preliminary design (PDR)			□	□
3.	Critical design (CDR)			□	□
4.	Mission readiness (MRR)			□	□
5.	Ground segment design(GDR)			□	□
6.	Ground segment test results			□	□
7.	Data utilization plan			□	□
8.	Failure analysis			□	□
9.	Post launch operations			□	□

Table 10-3: Checklist of Documents

S.No	Documents	Date	Time line	Done
1.	Baseline design documents		BDR	□
2.	Trade off Document		BDR	□
3.	Specification Document		PDR	□
4.	Preliminary design documents		PDR	□
5.	Critical design documents		CDR	□
6.	Mission readiness documents		MRR	□
7.	Ground segment design document		PDR	□
8.	Ground segment test results document		CDR	□
9.	Data utilization plan document		MRR	□
10.	Failure analysis document		CDR	□
11.	Interface Control Documents		PDR	□
12.	Sequence of Events document		MRR	□

Table 10-4: Checklist of Test & Evaluation

S.No	Test & Evaluation	Date	Results Document	observati ons	Done
1.	Bread board model T&E		□		□
2.	Bench level		□		□
3.	Engineering model		□		□
4.	Flight model		□		□
5.	OILS		□		□
6.	Dis assemble model		□		□
7.	Assemble model		□		□
8.	Ground segment compatibility		□		□
9.	Polarity		□		□
10.	Thermo vacuum		□		□
11.	Vibration		□		□
12.	PSLV compatibility test		□		□

Table 10-5: Checklist of Clearances

S.No	Clearances	Date	Done
1.	Frequency clearance		□
2.	Frequency clearance with PSLV		□
3.	Accommodation clearance with PSLV		□
4.	Safety Clearance		□
5.	Material Clearance (Degasing etc)		□
6.	All committees clearance		□

Part-2C

Design and fabrication of satellite by Universities/ Institutions

CONTENTS

1. INTRODUCTION

This part describes different topics and description to be covered in satellite proposal document for option-3. Tests to be conducted, documents to be generated during the satellite development are listed in this book.

The list of essential topics required for proposal evaluation is provided in following table1.1. Proposal may have additional topics if required. Each topic shall have technical write-ups, block diagrams, tables etc. to explain the design of each subsystem.

The second chapter of this document explains the information to be provided under each topic of the proposal. Minimum information required is given as typical write-up.

Further chapters provide additional information on satellite fabrication process and related activities

Table 1.1 Format for student satellite initial proposal

S.NO	PROPOSAL FORMAT
1.	Introduction
2.	Mission Mission Objective Mission specifications Payload selection Orbit Selection
3.	Payload Scientific aspects of Payload Payload Configuration Payload Specifications Bus Configuration Student satellite Bus systems - structure, thermal, mechanism, onboard computer, on board software, power, RF systems, sensors, actuators and control algorithms
4.	Manpower & Organization (Project leader, designers, etc)
5.	Project Management Plan
6.	Schedule
7.	Internal review mechanism (Members list)
8.	Budget
9.	Users/Project Partners
10.	Data processing and usage plan
11.	Data dissemination plan to users
12.	Ground Segment

2. PROPOSAL DOCUMENT - TOPICS DESCRIPTION

This chapter describes the information to be provided under various topics of the proposal.

2.1 Introduction

The introduction chapter of the proposal should cover about the University/ Institution which proposes the satellite. Importance of the proposed satellite can be explained here.

2.2 Mission

The proposal should provide the mission objectives clearly in this chapter. The relevance of the objectives to the society and science also can be stated.

Points to be considered during the mission objective selection are as given below.

- Innovation in the payload & Bus design
- Financial support available,
- Facilities available at universities
- Cost estimation
- Continuous manpower availability for project
- Commitment from Management, Faculty and Students
- Segments of project (see Annexure-1)

2.2.1 Mission objectives

The Mission objective should reflect the motive of this mission and any spin-off utilization due to it etc

The mission objective format is as given below

- To design, develop, and launch a Payload to observe ....
- Using the payload data for estimating ....
- Using the payload data for study the frequency of occurrence of ....
- To gain expertise in design, development, testing, maintain a satellite on orbit

<u>Typical Mission Objectives (Example) are</u>

- To observe the forest for their density, type of trees, area variation due to season, area variation due to infrastructure development
- To gain experience in design, fabricate, test and operate satellite
- To gain experience in design a multispectral camera
- To gain experience in system engineering and team work

2.2.2 Mission specification

The mission specifications are derived from the mission objective
The Typical mission specification are as follows

The spectral band :
Look angle :
SNR of the Instrument :

Example(typical values

No. of Spectral Band required :2

Band -1 : 0.62-0.68 micron
Band-2 : 0.77-0.86 micron.
Resolution : 50 m
Swath : 300 Km

(Reason for selection of these values to be explained)

2.2.3 Payload specification

This section provides the payload specification to meet the Mission Specification. It has to give the scientific concept utilized in the payload and its suitability for the mission objective.

Example (typical values)

No. of Spectral Band required :2

Focal length : 200 mm
FOV : +/-12 deg.
Detector : 4096 element CCD

2.2.4 Orbit selection

All Student satellites will be launched as auxiliary satellites with main satellites. The orbit selection will be based on main satellite requirement. Preferably the student satellite mission should be orbit independent or should be tuned for an ongoing program and main S/C identified.

- If payload choice for student satellite is orbit specific, the launch opportunities will be limited.
- If it is polar sun synchronous orbit, launch opportunity will more.

A typical format for orbit is given below

Orbit Type	:	Polar / near equator
Local time	:	10.30 AM
Altitude	:	above 500 Kms
Inclination	:	~98 deg.
Life	:	~1Year

2.3 Spacecraft configuration

The spacecraft configuration provided in the proposal should have a brief description of all subsystems. The components/bill of materials shall be provided in the proposal.

All proposals should have a description about the payload and its usage.

2.3.1 Major specifications

The specification topic of proposal should provide major specification of proposed satellite.

A typical format is given below

Mass	:	<15 Kg
Bus mass	:	< 8Kg
Payload mass	:	< 7Kg
Dimensions		
Bus	:	100 x 100 x 100 mm^3
Payload	:	50 x 50 x 75 mm^3
Reliability	:	0.7 for 1 year
Orbit Type	:	Polar / near equator
Local time	:	10.00 AM
Altitude	:	above 500 Kms
Inclination	:	98 deg.
Life	:	~1Year

2.3.2 Payload configuration

This section should contain all the retails pertaining to payload configuration including electrical, Mechanical, thermal aspects etc.

2.3.3 Structure

The description of the structure is to be provided in this section. Relevant drawings and materials considered can also be provided here.

Typical: The structure acts as a skeleton for spacecraft, which is made up of Aluminum alloy. All electronic packages/PCBs can be mounted on structure, which will protect those packages from launch loads.

2.3.4 Thermal control

The description of thermal system is to be provided in this section.

The temperature of electronic packages needs to be maintained in the range of 0° to 40°C.

Thermal control system consists of passive elements like heat sinks, Optical Solar Reflector (OSR), Multi-Layer Insulation blanket (MLI), and thermally conducting grease, used wherever required

Thermistors are used for temperature monitoring at required locations. The temperature sensor data is processed in OBC for telemetry. For the packages with high power dissipation, a good contact will be assured with the deck by providing thermally conducting grease. The spacecraft will be thermally insulated using MLI blanket with sufficient window cut-outs. These window cut-outs will have OSR to dissipate excess heat to space.

2.3.5 Power system

The description of power system is to be provided here.

Typical write-up

The power supply unit is a fully autonomous system that receives power from the solar panels with number of solar cells, conditions and distributes this power to a various electronic subsystems on board the satellite. The battery is required to support the satellite systems in eclipse. It will be charged during the sunlit and used in eclipse. The power generated in sunlit has to support the satellite in sunlit and charge the battery.

Power system consists of

- Power Control unit
- Solar panels
- Battery

Power Control Unit

Major functional parts of Power control unit

- Output Voltage Control
- User Protection
- Emergency
- ON / OFF of Individual sub-system
- OBC Communication Interface
- Communication of House-keeping Information
- Communication of User On/Off status
- OBC Boot Selection Interface

Power Budget & Solar Cell Area

Power Generation details should be provided in the proposal document..

Different topics to be covered are

Power or (Energy) Budget

System	Power required	Operation time / orbit	Energy required

Solar cell Area :
Power Generated during Sunlit :
Power required per orbit (sunlit+eclipse) :
Peak power :
Peak power duration :
Margin available :

Battery

Based on the power budget calculation, the battery capacity is to be provided here.

2.3.6 On Board Computer (OBC)

The design of spacecraft electronics should aim to consume less power, achieve less weight, and occupy less volume. With the advent of high speed processors, FPGAs, it has now become possible to integrate all-digital functions such as command , house-keeping telemetry,, attitude and orbit control, thermal management, Gyro processing, and Magneto-meter data processing etc., into a single unified integrated spacecraft electronics unit, known as spacecraft On Board Computer. The OBC will be built around the state of the art technologies and it will interface with TTC (RF), sensors, power, MTCs, Mems Gyros, Nano Wheels and payload for command and housekeeping telemetry functions.

The main functions of the OBC are

- Tele command processing
- Attitude and health Sensors data acquisition and processing
- Attitude and Orbit determination
- Attitude correction
- Telemetry and Housekeeping
- Thermal management
- Spacecraft autonomy
- Base band Data handling
- Acquiring and Storing the Payload data and transmitting

OBC Requirements

The various tasks that the On-Board Computer sub-system can perform on the flight model are listed in this section. Efficient and reliable execution of these tasks is the primary motivation for the design of the On-Board Computer sub-system.

2.3.6.1 Monitoring and status checking

- Health monitoring – Monitor the health of the various subsystems of the satellite database. If a particular sub-system is not working, shutdown all functions and programs related to it and switch OFF particular subsystem.
- Status maintenance – Maintain the status of the devices, i.e, if the device is busy or available. If a device is busy, prevent it from shutting down by other subsystems.
- It should Coordinate with all related subsystems

2.3.6.2 Command interpretation

Receive the commands from the ground station via the communication unit and decode, interpret and execute them and send the results back to the user.

2.3.6.3 Device control and Management

- Monitor power level of the system, and the available power.
- Power 'ON' and 'OFF' devices as and when required.
- Have a device priority table. In case of power crisis, shut down the low priority devices to save power.
- Acquire sensor data at intervals mentioned in configuration table.

- Store sensor data in a table.
- Read data from sensor table, interpret it and order actuators to take actions.

2.3.6.4 Payload controller

- Get payload data from payloads and command them for dumping and when required.
- Interpreting the command from ground station for payload control.
- Collecting the information from payloads

2.3.6.5 Processes management

- It has to keep track of processes. Kill and restart processes when necessary. If everything fails, reset the system. If the reset fails, start the other board.
- Start and shutdown processes as and when needed to conserve power.

2.3.6.6 Pre-launch phase requirements

The On-Board Computer sub-system is required to conduct pre-flight checks to confirm the operational status of all important components (like the SPS unit). The health status of a number of components will be monitored and stored while the satellite is in orbit. This "House-keeping" Data (or HK data) will consist of Attitude data, position data, data regarding various loads as seen by the power sub-system, and the associated systems with timestamps.

2.3.6.7 Attitude Determination and Control algorithms

The Controls subsystem is primarily concerned with determining the satellite's attitude. The On-Board Computer is required to interface with sensors and actuators and execute the control-law calculations that determine the required actuation from the current attitude.

2.3.6.8 Sensor Interfacing:

The On-Board Computer is required to interface with the following sensors:

1. Satellite Positioning System (SPS) Unit (If required)
2. Magnetometer
3. Sun-Sensors (4 Pi)
4. IRU or any other sensors.

2.3.6.9 Control Law Execution:

The On-Board Computer shall execute the control law as designed by the Controls sub-system. This includes performing the requisite numerical calculations with the desired accuracy as well as according to the predefined sequence.

2.3.6.10 Actuation:

The On-Board Computer has to interface with and actuate the magnetic torquers and nano wheels according to the control law. This implies provision of suitable pulse-width-modulated signals for suitable time intervals.

2.3.6.11 Power

The power subsystem is concerned with acquiring, regulating and distributing power to the various subsystems of the satellite. The Power and On-Board Computer subsystem must interact with all sub-systems exchange data about power systems health.

2.3.6.12 Response to low-power situations

The Power subsystem generates a signal indicating the load beyond expected to the On-Board Computer subsystem. The On-Board Computer subsystem is required to recognize this signal as a hard interrupt and initiate suitable shutdown measures. The data exchanged regularly between the Power and On-Board Computer subsystem will indicate any misbehavior on the part of any component. The On-Board Computer will respond with suitable redundancy measures.

2.3.6.13 Communication and Ground-Station

For the purposes of monitoring the status of the mission, the satellite will transmit the health of the various components during downlink. In this regard, the On-Board Computer sub-system is required to send the health data in packets encoded using the communication protocol, at designed rate whenever the satellite is over the Ground-Station.

2.3.7 Attitude Determination and Control System (ADCS)

Typical ADCS write-up should cover specification, systems involved and their expected roles etc.

The ADCS is part of the OBC caters to 3-axis body stabilized spacecraft with reaction wheels and magnetic torquers.

Pointing, stability and jitter requirements

- Pointing accuracy : (payload dependent)
- Stability : (payload dependent)

2.3.7.1 ADCS configuration

It consists of various types of sensors for measurement of attitude errors, control electronics and different types of actuators such as reaction wheels and magnetic torquers to impart thrust/torque to the spacecraft in the desired direction.

2.3.7.2 Sensors configuration:

The Sensors system consists of 4Pi sun sensors, Magnetometer, Digital sun sensor and various temperature sensors. The list of Sensors used and their functions are given in table.2.1

Table 2-1: Sensor Configuration

S.No	Sensor	Output	Used for
1	Tri–axial Magnetometer	Measurement of local geomagnetic field	Attitude determination
2	4-π Sun sensor	Pitch and roll errors	Attitude determination
4	IRU (MEMS)	Yaw, roll and pitch incremental errors	Attitude determination

2.3.7.3 Actuator configuration

The actuators are used to control the attitude of the spacecraft. Two types of actuators are used in nano satellites namely, reaction wheels and magnetic torquers.

Table 2-2: Actuators configuration

Sl. No.	Actuator	Purpose
1	Magnetic Torquers (2 Nos of 2.0 A-m^2)	a. Detumbling b. Momentum dumping of wheels
2	Reaction Wheels	a. Attitude Acquisition for Sun- Pointing Orientation b. Normal Mode (Non-Imaging and Imaging) c. Orbit Manoeuvre for Attitude Control

2.3.8 RF systems

The RF system description is to be provided here

The write-up has to cover the design, configuration of antenna, beacon transmitter, Telemetry and Payload data transmitter, telecommand receiver, and Satellite positioning system etc.

2.3.8.1 Beacon Downlink

- Beacon is a low data rate signal. It would include call sign of Nano, limited health status of Satellite etc.
- Beacon will be ON throughout the orbit. So that beacon is available to the amateur community all around the world for signal reception.

2.3.8.2 Data downlink

- Data consists of P/L data, House Keeping(HK) data from various other subsystems as well as satellite health parameters

2.3.8.3 Uplink

- Commands to ON / OFF any sub-systems manually
- Commands to operate payload etc.
- To uplink orbital parameters

2.3.8.4 Satellite positioning system (SPS)

The satellite positioning system details can be provided here if flown.

- This is mainly used for orbit determination and time correlation .

2.3.8.5 Frequency clearance

Frequency clearance is the responsibility of the owner of the satellite. Since educational satellites are basically designed and developed by Universities, the frequency clearance is to be obtained by the respective University or Institution. For all educational satellites, it is recommended to operate in HAM/ amateur band. The University/Institution needs to apply and get permission for the usage of chosen frequencies in UHF and VHF bands with IARU (International Amateur Radio union).

2.3.8.6 Antenna

Monopole antennas / helical antenna / patch antenna can be selected depends on the requirement.

2.3.9 PSLV interface

Student satellites can utilize any one of the following four different standard ejection systems.

- 1 Unit ISRO made ejection system (10 cm X 10 cm X 10 cm)
- 2 Unit ISRO made ejection system (10 cm X 10 cm X 20 cm)
- IBL-230 – ISRO:VSSC
- Standard qualified 3 Unit proven ejection system (10 cm X 10 cm X 30 cm) from any other sources. (acceptable if conforming to ISRO Quality norms)

2.3.9.1 ISRO made ejection system (1Unit)

Specifications:

Dimensions	:	10 cm X 10 cm X 10 cm
Mass	:	2 kg (Structure + satellite)
Satellite mass	:	1 Kg

2.3.9.2 ISRO made ejection system(2Unit)

Specifications:

Dimensions	:	10 cm X 10 cm X 20 cm
Mass	:	3 kg (Structure + satellite)
Satellite mass	:	2 Kg

2.3.9.3 IBL-230

IBL-230 designed and developed by VSSC, ISRO. Caters to micro / Nano satellites of mass **10kg to 50 kg** under axial & lateral accelerations of **11g & 6g** respectively. (Axial CG offset 420mm for 50kg satellite).

Table 2-3: Spacecraft Interface on FE Ring

SYSTEM	SPACECRAFT INTERFACE ON FE RING				Overall Height (mm)	FE Ring Height (mm)	Flange Thk (mm)
	Mounting PCD (mm)	Mounting holes	OD (mm)	ID (mm)			
IBL-230	230	ϕ6, 6 Nos	286/246	190	60	42	3.5

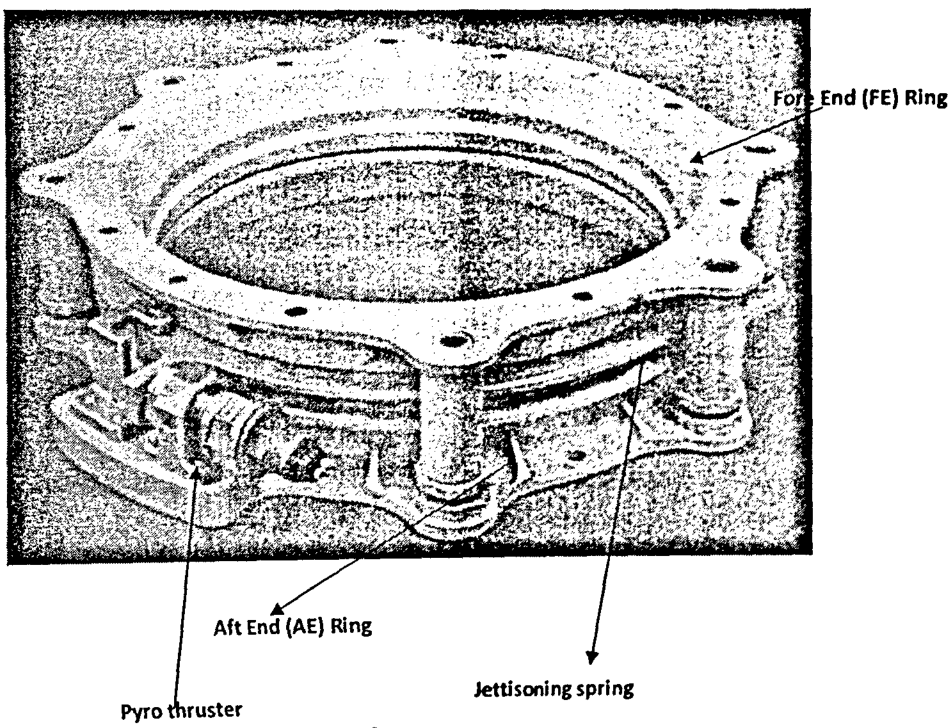


Figure 2-1: IBL-230 before separation

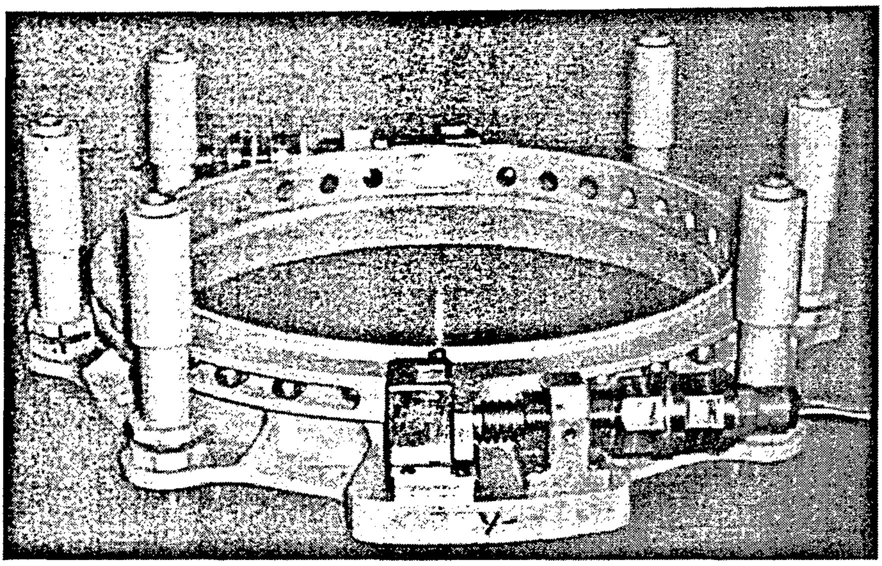


Figure 2-2: IBL-230 after Separation

2.4 Manpower & Organisation

The Satellite team should comprise system engineer, faculty, research scholars and students. The system engineer, who has over all knowledge of satellite systems from university / Institutions, will be the in-charge for student satellite development. He may be supported by faculty and research engineers from various relevant departments for the internal reviews and guidance.

Student coordinator, who will have overall knowledge of the spacecraft and in-depth knowledge of the system concerned, is to be identified for interaction among various sub-systems and with ISRO. The list of faculty system engineer and student coordinators is to be provided to ISRO with the proposal.

The students from 2nd year to 4th year of all related disciplines have to be included in the team. This will help them in transferring the information from seniors to juniors. The structure of typical team is as given in **Figure 2-3**

Sufficient students are required for design, development, qualification, fabrication, system engineering, testing etc. of subsystems satellite and ground segment.

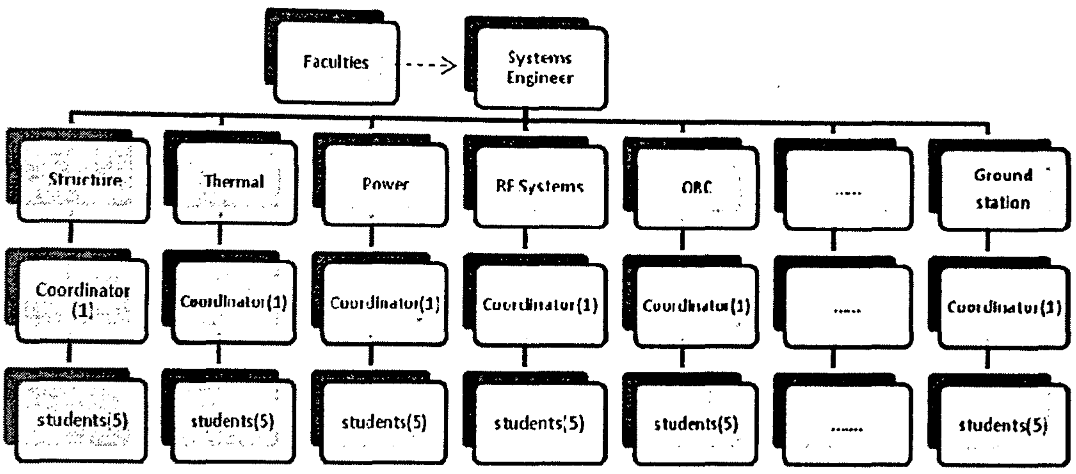


Figure 2-3: Project organization chart

Table 2-4: Team Identification (suggested)

S.NO	SUB SYSTEMS	STUDENT Coordinator	STUDENTS (approx.)	PROFESSORS/ASST. PROFESSORS
1.	System Engineer	1	2	1
2.	Structure	1	4	1
3.	Thermal	1	4	
4.	Power system	1	4	1
5.	RF System	1	4	
6.	On board computer	1	4	1
7.	On Board Software	1	4	
8.	ACS	1	4	1
9.	Sensors	1	4	
10.	Actuators (RW)	1	4	
11.	Ground Segment	1	4	1
12.	Payload	1	4	1
13.	R & QA	1	4	-
14.	Total	13	50	7

2.5 Project Mamangement Plan

The detailed project management plan consisting executive committee, different advisary boards, their heirarchy, frequency of their review etc. can be provided here. Configuration change control, tracking, information dessemination methods etc should be provided in this section.

2.6 Schedule

The studies show that the approximate time required for the satellite launch from the Preliminary design review is 2 to 3 years and data utilization duration after launch of satellite is 1 to 2 years.

The institutions/Universities entering into Space mission should have a plan for this full life cycle in terms of manpower, facility, budget etc.

Typical Schedule chart is provided below

	Events	**Time line (months)**
1.	Submission student satellite proposal	T_0 - 4
2.	Project Approval	T_0 - 3
3.	S/C Mainframe Configuration finalization	T_0–2
4.	Submission of PDR documents	T_0 -1
5.	Preliminary Design Review of S/C	T_0
6.	MOU	T_0
7.	Applying for frequency clearance	T_0
8.	Engineering model of all sub-systems (Including payload)	T_0 + 6
9.	CDR for All systems	T_0 + 6
10.	Flight model S/S readiness	T_0 +18
11.	Availability of frequency clearance certificate	T_0 +18
12.	Payload delivery	T_0 + 18
13.	Integrated S/C readiness	T_0 + 20
14.	S/C IST& environmental tests	T_0 + 23
15.	PSR of S/C	T_0 + 23
16.	Handing over satellite to PSLV	T_0 + 24

Note: On satisfied completion of PDR, the committee will recommend for MoU and it will be executed as per the time convenient to ISRO.

2.7 Internal Review Mechanism

Internal technical review committees list and review mechanism is to be proveded here.

2.8 Budget

Budget required is dependent on size, mass and complexity of the satellite.
Approximate estimated cost of satellite based on classification as given below

S.No	Classification	Cost in Rs
1.	Microsat (<50 Kg)	10-15 Crores
	Nanosat (<15 Kg)	1-3 Crores
	Picosat (<1 Kg)	<1 Crores

The above information is provided to universities to make them aware of the financial obligation. No financial support will be provided by ISRO.

The Picosatellite fabrication may cost ~ 1 Crore as on today. Budget allocation for various activities can be provided here in table form.

A Typical Budget allocation table is given below.

Budget summary			
		Allocation [Rs in lakhs]	
Sl no	Elements	Total	FE
1	Project elements	40.00	23.00
2	Program elements	25.00	10.00
3	Customs duty	10.00	0.00
Total project cost		75.00	33.00

Budget summary – project elements			
		Allocation [RS in lakhs]	
Sl no	Subsystem	Total	Fe
1	Structure	2.00	0.00
2	Thermal	1.00	0.00
3	Mechanisms	1.00	0.00
4	RF systems	1.00	1.00
5	OBC	2.00	2.00
6	Power system	1.00	2.00
8	Sensor systems	1.00	1.00
9	Integration system	1.00	2.00
10	R & QA	1.00	0.00
11	Mission planning	2.00	0.00
12	ETF/EFF/MFF	2.00	5.00
13	Payload	5.00	10.00
14	Logistic	10.00	0.00
15	Administration	10.00	0.00
Project element total		40.00	23.00

Budget summary – program elements			
		Allocation [Rs in lakhs]	
Sl no	Subsystem	Total	Fe
1	Ground elements	10.00	5.00
2	Facilities	10.00	5.00
3	Payload data processing	5.00	0.00
Program elements total		25.00	10.00

2.9 Users/project Partners

If there is a plan to share the payload data among other universities and colleges, a list of users can be provided here. More number of users participation is encouraged.

2.10 Data Processing and Utilisation Plan

Plan of data processing, Data analysis, Data product generation, method and data utilization plan shall be provided here.

2.11 Data dissemination plan

The data dissemination plan to the users to be provided here.

2.12 Ground segment Design

The Ground segment consists of satellite control system and Payload data reception & processing system.

The control system includes command generator, transmitter,antenna to command the satellite and receiver, data interpreter to receive and analyse the house-keeping data. The hardware and software planned is to be described here.

The payload data reception centre should have suitable system with receiver and antenna etc. It should have software hardware to analyse the payload data.

3. SPACECRAFT TESTING

This chapter provides various tests to be conducted on subsystem and satellite.

The testing is based on the type of systems and way of system realization. The subsystems can be realized by two different ways

1. Buying space heritage systems from standard manufacturer and integrating
2. Developing with COTS components

If any subsystem is bought from standard vendor and the system is space proven, it will be tested for its performance and integrated with satellite.

If the subsystem is designed and developed by universities, system development has to follow breadboard model, engineering model and flight model.

ISRO encourages the indigenous design and development of systems.

3.1 Electrical Test &Evaluation

Each flight model subsystem should undergo full functional tests and full compliance to system specifications under prescribed environmental conditions. Test & Evaluation of each subsystem is required for verification of design margins, weeding out parts / materials / workmanship defects in order to ensure successful operational use of integrated spacecraft. Test results at each stage should be documented.

3.2 OILS Test

Complete integration of ADCS components like OBC, sensors, IRU, RWs under go in loop dynamic simulations before certifying the subsystems for integrating with S/C.

3.3 Integrated Spacecraft test (IST)

3.3.1 Dis assembled and Assemble mode IST

In disassembled mode testing all systems are connected electrically but not integrated mechanically. In the case of assembled mode, all systems are integrated electrically and mechanically. Following tests are to be conducte on spacecraft.

- End to end checks for each subsystem before and after spacecraft integration.
- Polarity checks for sensors.
- All subsystems functional and performance test in clean room environment in integrated condition.
- Battery emergency checks,
- All sub-systems interface compatibility checks to be carried out.
- Ground station compatibility test with EM or FM

After successful completion of these tests the spacecraft should undergo environmental tests integration. In the case of any deployable systems, they should be designed in such way that they can be stowed back without disturbing the spacecraft.

3.3.2 Environmental tests

To validate the performance of the integrated spacecraft under the simulated lift off and on orbit conditions. After successful environmental test the spacecraft should not be dis-assembled. In case of any failure, if spacecraft is dissembled for any correction, again environmental tests should be conducted to ensure the functional performance.

Thermo vacuum test

This test is carried out to validate the performance of all the on board sub systems under simulated adverse vacuum and temperature conditions. It uncovers the deficiencies in parts, workmanship and intra system interface compatibility under extreme conditions of temperature and vacuum. The Chamber is maintained at -100°C always to simulate the space temperatures. S/C can be heated by using IR lamps. Each sub-system undergoes T_{min} in cold cycle / soak and T_{max} in hot cycle / soak. Typical temperature profile is provided in Annexure-2

Vibration test

The typical vibration levels of PSLV launch vehicle is provided below. The student satellites should be designed and tested for these values.

Stiffness requirements (TBD)

Lateral frequency : ......Hz

Longitudinal frequency : ..... Hz

Quasi static loads (TBD)

Longitudinal acceleration :....g

Lateral acceleration :......g

Load factor :.....

Both loads acts simultaneously at CG of spacecraft.

Sine Vibration test levels (TBD)

Random vibration test levels (TBD)

3.4 Ground Segment Compatibility Test

Prior to commencement of pre-launch simulation, test and evaluation of entire ground segment should be carried out. Functional compatibility checking of ground stations with the satellite should be carried out successfully and test results to be documented & presented to the PSR committee.

3.5 Pre-Launch phase activities

Prior to handing over satellite to PSLV team, the following activities / test should be carried out.

- End to end checks
- Battery charging
- Final thermal work
- Removal of all non-flight components

4. FACILITIES REQUIRED AT UNIVERSITIES

4.1 Clean room

University should establish a clean room with following specifications to integrate, test and store the spacecraft.

Class	:	100000,
Area	:	200 sqft (min),
Humidity	:	55±5%
Temperature	:	20±5°C

All ESD protection guidelines has to be followed for establishing clean room

4.2 Laboratory & Components stores

University/Institution should establish a Laboratory& Components stores with following specifications to perform bench tests, to store procured components / modules / sub-systems.

Area	:	200 sqft
Temperature	:	20±5°C

4.2.1 Equipments required

Laboratory must have following equipment / tools

- Spectrum analyzer
- Oscilloscope
- Power meter
- Tool kit
- Power supply
- Multi-meter etc.

4.3 Work shop

University should establish an electrical and mechanical work shop for fabrication related activities (soldering, PCB fabrication, Mechanical fabrication, and materials storage).

4.4 Hot and cold / thermovacuum chambers

Preferably, universities may establish hot and cold / thermovac chamber. However ISRO facilities can be used for Engineering and Flight Model testing.

4.5 Vibration lab

Preferably, universities may establish vibration test facility. However ISRO facilities can be used for Engineering and Flight Model testing.

4.6 ESD protection equipment

- Antistatic Coat
- Antistatic Mat
- Antistatic Flooring
- Antistatic Chairs

- Wrist bands

4.7 Ground station

Ground Station should have the following features:

- Command transmission and P/L data and telemetry reception
- Tracking of the satellite
- Data acquisition and storing
- Display of satellite position
- Display of health monitoring and performance of the satellite
- Maintenance and support
- Data processing and usage
- Data dissemination plan to users

Health data processing software should process the spacecraft telemetry data and display spacecraft. Any value deviating from expected range it has to generate an alarm.

Utility software should support following utilities.

1. Selected parameter print out,
2. Master frame print out,
3. Real time graphics on terminal and
4. Near-real time graphics plotting.

Archival software should take care of merging real time & playback data and store for future use.

Ground station compatibility test must be demonstrated with engineering model and live satellites to ensure the ground station readiness.

5. ISRO SUPPORT & UNIVERSITY RESPOSIBILITIES

ISRO will provide guidance, consultancy and support for design and also during developmental phase of educational satellites. The guidance is in the total systems engineering of the satellite. Consultancy in specific technology issues critical for the success of design of the sub-systems, Support could include limited critical components or materials, solar panels and batteries that may not be possible to be procured by the Institutions especially. ISRO also conducts identified periodic reviews and help the institution in the project management, if required.

5.1 ISRO's Responsibilities

- Providing the critical materials as listed in table 5.1
- Conducting reviews
- Providing integrated satellite test support (ThermoVac, Vibration, Clean room)
- Launching the satellite

5.1.1 Components

The Institution/ Universities are responsible for all components procurement, fabrication and functional test of the spacecraft. The list of items / components provided by ISRO is given below

Table 5-1: Materials support

S.No	Materials
1.	Solar Cells
2.	Li ion Battery
3.	Multi-Layer Insulation
4.	OSR
5.	Low emittance tape
6.	Kapton Tape
7.	Thermistors

5.1.2 Review

The design development and test results will be reviewed by the Standing Review Committee appointed by ISRO.

5.1.3 Facility

Universities/Institutions can utilise the critical test facilities (Thermovacuum & Vibration) of ISRO.

5.1.4 Test Equipments

All the test equipment required to test satellite should be brought by University/Institution.

5.1.5 Frequency clearance

Frequency clearance is the responsibility of the owner of the satellites. The University/Institution needs to register the chosen frequencies in UHF and VHF bands with IARU (International Amateur Radio Union).

5.1.6 Contact Details

Email: stu_sats@isac.gov.in.

Phone: 080-2508-2431/ 2508-2696 / 2508-2697

Postal Address:

The Programme Director, IRS & SSS
ISRO Satellite Centre
Vimanapura P.O
Bangalore – 560 017

Before any scheduled review, there may be a visit of ISRO exports to universities / institutions based on requirement. All logistics supports to be provided by universities.

Publicity and press related:

Universities / Institutions should not publish the student satellite project information (Technical &managerial) to any journal or news agencies without ISRO's written permission.

Security related issues:

Important reviews will be conducted at ISRO. Nominally, following items are prohibited inside the ISRO campuses.

1. Laptops
2. Mobiles
3. Memory sticks
4. Camera
5. Calculators
6. Any electronic items

However, for presentation purpose one Memory stick / Laptop may be allowed if prior intimation is given.

6. REVIEWS

6.1 Introduction

Project implementation has various phases like Study, Spacecraft Configuration Definition, Design and Development of sub-systems, Qualification of the Engineering Model, Fabrication and Acceptance Testing of the Flight Model. At the completion of each of these project phases, detailed reviews are held. The review team will be chaired by an expert in spacecraft technology who is not directly connected with the project. The members of these review teams are drawn from various specialised disciplines. The reviews termed as the Base Line Design Review, the Preliminary Design Review, the Critical Design Review and Pre-shipment Review are conducted.

Reviews will be conducted at ISRO or at universities based on the requirements. As all experts and student satellite members may not be able to attend the reviews in person, video conferences are preferable. The video conference facility at University end is desirable and helpful in reviews and discussions.

6.2 Design Reviews

6.2.1 Baseline Design Review (BDR)

This is the conceptual design review. Universities have to design the satellite bus and payloads. This review includes the trade-off study also.

The BDR marks the completion of the study phase. Inputs to the Base Line Design Review provided by the project team comprises of the following:

- Payload and mainframe subsystems configuration trade-offs and the configuration chosen. Restraints and demands on spacecraft platform.
- Power and Mass budgets
- Reliability apportionment
- Materials, components and process related issues regarding availability, qualification and reliability levels
- Complete requirements at subsystem and system level.

The recommendations by the BDR Committee constitute the baseline of the configuration options and give the go-ahead for the development of breadboard models/ feasibility models.

6.2.2 Preliminary Design Review (PDR)

This Review covers the Bread board model results of various subsystems. The tests will be conducted as individual system. On satisfied completion of PDR, the committee will recommend for MoU and it will be executed as per the time convenient to ISRO.

This review will be held after the breadboard model activity of the new subsystems is completed and a preliminary design is made available to the project. Recommendations of the PDR committee include configuration/design modifications required in order to meet the specifications and for the removal of possible single point failures, the verification of adequacy of the quality of the components

6.2.3 Critical Design Review(CDR)

The CDR covers the test results of the sub systems at various stages like bench level test, thermo-vacuum, and vibration test of engineering model.

The CDR is held after the Engineering model of the satellite /subsystems has been subjected to various environmental tests and the test results are available. The recommendations by the CDR committee are on possible solutions to the problems and additional tests to be conducted, if required and giving the go-ahead for the realisation of the flight model.

6.2.4 Pre-shipment Review(PSR)

This review will be conducted before the movement of the satellite to the launch pad. This review covers the satellite performance in assembled mode, vibration test and thermo-vacuum test of flight model.

The PSR committee reviews the following aspects: -

- Action close-out of the previous reviews
- Detailed flight spacecraft level test results, problems faced and corrective actions taken and the outstanding deviations and their mission Impact
- Subsystem test results of spare flight model. Problem analysis and corrective actions taken.
- Ground segment test results
- The PSR committee addresses the outstanding issues and recommends modifications to be carried out if necessary and provides the clearance for shipping the spacecraft to the launch base.

6.2.5 Ground Segment Review(GSR)

This Review covers the readiness of Ground systems like TTC and Payload data reception systems.

6.3 Work Based Reviews

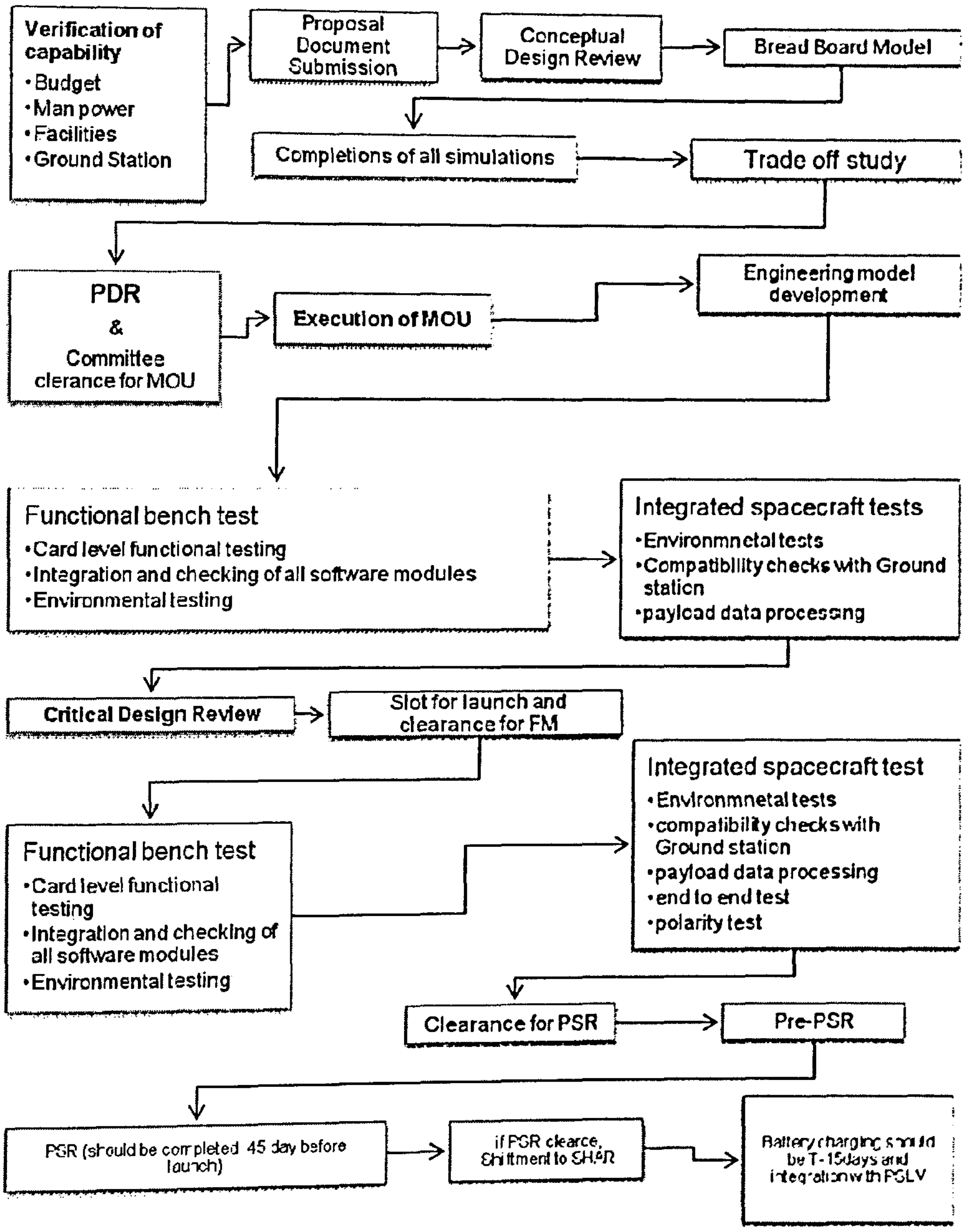
6.3.1 Test Results Review

These reviews are conducted when the tests are completed at each stage.

6.3.2 Failure Analysis Review

These reviews will be conducted when some component failed. The fabrication /test/ storage conditions are reviewed.

6.4 Realization steps in student satellite project



7. RELIABILITY AND QUALITY ASSURANCE

Throughout the spacecraft design and realization product assurance ensures quality and reliability. Among the major components of product assurance are reliability engineering, parts, materials and process control program, test and evaluation, failure analysis, and non-conformance management. Milestone reviews such as the Preliminary Design Review (PDR) and Critical Design Review are conducted to ensure spacecraft reliability.

7.1 Risk Management

7.1.1 Modularity

The spacecraft design should be such that any sub-system card failed at any moment can be replaced with spare card, ie., system design should be with modular approach. Every card / system should have spare, identical to Flight Model. This approach will avoid prolonged delay due to sub-system failures.

7.1.2 Testability

The spacecraft design should support testing any sub-system without disassembling the satellite.

7.2 Reliability Engineering

Reliability assessment will be carried out using data that include the subsystem block diagram, component list and component quality level, and the mission life by university / Institutions.

7.3 Parts Control

In general, **COTS (Commercial off the Shelves)** components will be used.

The degassing material will affect optical instruments of the student satellite and main satellite. So the bill of materials to be produced to ISRO and get clearance before using them for fabrication.

7.4 Materials and Process Control

ISRO suggested materials will be used. The chosen materials will also meet the necessary magnetic cleanliness criteria. All materials will be subjected to incoming inspection.

All major processes such as PCB fabrication, electronic assembly, harness fabrication, etc. will be done by University/Institutions or ISRO qualified vendors.

7.5 Test and evaluation

Functional and environmental tests will be conducted on equipment after realization. These tests are designed and documented after considering individual test requirements. For purchased units, the appropriate test philosophy will be incorporated in the purchase specifications. Each of the subsystem units will be subjected to the expected EMI, thermal and vacuum, and dynamic environments, as per the environmental test specifications document.

7.6 Spacecraft-level Testing

Spacecraft level tests include functional tests, characterization and verification measurements, and environmental tests.

Integrated system level tests (IST) will be conducted to verify spacecraft system functioning in disassembled and assembled conditions as well as after each environmental test. EMI/EMC test will be conducted to clear electro-magnetic interference concerns. The spacecraft will undergo a thermal-vacuum test to verify system performance in space temperature and vacuum environment. Other environmental tests are sine and random or acoustic, vibration tests, and shock test as applicable.

Measurement of physical properties such as mass, position of the spacecraft center of gravity, and spacecraft moment of inertia will be carried out after complete integration of spacecraft. Spacecraft imbalance measurement and correction also will be conducted in completed spacecraft configuration. Sensors alignment measurement and correction, wherever necessary, also will be conducted prior to and after the dynamic tests. Launcher interface verification to ensure trouble-free integration of spacecraft to the launcher also will be conducted at an appropriate phase of spacecraft integration. Quality assurance also ensures health and suitability verification of electrical and mechanical ground support equipments (EGSE and MGSE). Major EGSE includes checkout computers, power supplies, battery and solar panel simulators, and uplink/downlink equipment. MGSE comprises integration fixtures and handling systems for equipment and spacecraft as well as transportation containers.

7.7 Configuration Management and Document Control

Subsystem and spacecraft configuration management and control will be ensured by the focal points identified from the subsystem groups, quality assurance and the Systems engineer. Drawing and document revisions will be controlled with a mechanism to annul older versions and to disseminate the most recent versions to all project executives.

8. DOCUMENTS

Documents are the guides to the systematic development of systems. The documents are important instruments which pass the information within the development team and from one semester students to next semester students. This chapter provides minimum number of documents required to be prepared.

8.1 Project proposal

The proposal document should contain the abstract, motivation and justification, system description, objective of the project both technical and service, time line, budget related and kind of support expecting from ISRO. The project proposal should also contain its goal, launch, mission management, orbit, life reliability.

It is essential that there should be a strong commitment by the Institution of the student satellite proposal. For a successful completion of the project strong and sustained commitment is essential from management, faculty and students. The project being primarily student driven, support of faculty from various departments is required. Before coming to ISRO for any review the local body must review and also few faculty members should also accompany the students and the detailed documents should be sent by mail four working days prior to the meeting.

8.2 Design documents

8.2.1 Baseline (Conceptual) Design Document

- The project team can be asked to come with a conceptual design review at ISRO premises for evaluation of their Project on specified dates.
- The detailed proposal sent by the Institution needs to be evaluated and graded for acceptance, conduct a preliminary conceptual design review.
- The Standing Review Committee (SRC) identified for the student satellite will review the proposal and also review the presentations and provide recommendations to the Apex Committee.

8.2.2 Preliminary Design Document

It should contain all the suggestions which are given in the Base line design review. It should have the complete layout drawings, circuit diagrams, interface related, formats, commanding information with codes, RF link margins, communication protocols.

8.2.3 Critical Design Document

This document is more detailed one and should contain all the test results of sub-systems for ISRO experts to review more critically.

8.2.4 Pre-Shipment Review Document

This is the final review where the total satellite will take place based on the test results provided by individual sub-committee chairmen. The shipment of the satellite for launch will depend on the PSR recommendation.

8.3 Interface documents

- Subsystem Interface definition document
- Electrical Interface document, Mechanical interface document

- Launch Vehicle Interface
- Ground Segment Interface (Data format etc.)
- Software Interface control document
- Thermal Interface control document

8.4 Mission operation document

- Mission operation/Sequence of Operation (SOE) document
- Launch phase operation document
- Contingency recovery procedure document
- Payload data processing and quality analysis document.

9. FABRICATION GUIDELINES

The advantage of a student satellite built by universities is using commercially available off-the-shelf components. In keeping with this practice, the components used for the spacecraft can be those that have been used regularly by students- no special space grade components need to be used. The practices for fabrication, on the other hand, will be those that are prescribed by ISRO and the system – including the printed circuit boards (PCBs) and the associated soldering in of components will be done at ISRO suggested facilities and will confirm to ISRO approved standards. The testing of the each sub-system comprises of multiple levels.

The software and hardware comprising of each interface has been tested individually with the associated components from the other sub-systems. This has been followed by the testing of the entire information pathway which links the power, on-board computer and communication sub-systems. This will be followed by On-board computer In Loop.

Universities / Institutions are responsible for fabricating structure and PCBs.

ISRO Satellite Centre has identified Industries for the spacecraft activities like Electrical Fabrication, Mechanical Elements Fabrication, Assembly of Packages and test etc. The Universities can select any one of the fabricator for spacecraft work.

9.1 Electrical

The PCB Design Guidelines can be obtained from the ISAC generated document Name "COMPLIANCE OF FOOTPRINT DESIGNS OF COMPONENTS USED IN ONBOARD PCB LAYOUTS" Reference No. ISRO-ISAC- ST-0125. This document can be obtained from ISRO.

9.2 Thermal

With the actual power dissipations for the satellite, thermal simulations need to be performed taking the orbit and attitude profiles, operation guides, sun angle variations, enough margins to be demonstrated for all the critical systems. The materials used, mechanical points needs to be simulated as close as possible to the realistic satellite. Passive control elements to be used for the thermal design as the power generated will be very less. Thermal simulations should demonstrate the thermal margins for all the critical systems considering the on orbit mission scenario.

9.3 Mechanical

Mechanical elements can be fabricated by Universities/Institutions as per the ISRO standards.

10. CHECKLISTS

The following table will be referred before recommending to MOU

Table 10-1: Check list for MOU

Sl.No	Check list for MOU	Marks	Weight	Final Marks
1	Mission goals			
2.	Orbit requirement			
3.	Project Team formation			
4	Configuration options selected			
5	Design margins			
6	Facilities available			
7	Capacity to spend the amount mentioned			
8	Technical Capability			
9	Conceptual Design Review			
10	Preliminary Design Review			
11	Ground Segment Plan			
12	Commitment to post launch activities			
13	Imported Item Percentage in design			
14	Other Institutions Participation			
15	Data utilization Plan			

Following tables will be referred before clearing for Shipment of Satellite to launch pad

Table 10-2: Checklist of Reviews

S.No	Reviews	Date	Reviews by	Actions Closed	Closeout Note
1.	Baseline design (BDR)			☐	☐
2.	Preliminary design (PDR)			☐	☐
3.	Critical design (CDR)			☐	☐
4.	Mission readiness (MRR)			☐	☐
5.	Ground segment design(GDR)			☐	☐
6.	Ground segment test results			☐	☐
7.	Data utilization plan			☐	☐
8.	Failure analysis			☐	☐
9.	Post launch operations			☐	☐

Table10-3: Checklist of Documents

S.No	Documents	Date	Time line	Done
1.	Baseline design documents		BDR	☐
2.	Trade off Document		BDR	☐
3.	Specification Document		PDR	☐
4.	Preliminary design documents		PDR	☐
5.	Critical design documents		CDR	☐
6.	Mission readiness documents		MRR	☐
7.	Ground segment design document		PDR	☐
8.	Ground segment test results document		CDR	☐
9.	Data utilization plan document		MRR	☐
10.	Failure analysis document		CDR	☐
11.	Interface Control Documents		PDR	☐
12.	Sequence of Events document		MRR	☐

Table 10-4: Checklist of Test & Evaluation

S.No	Test & Evaluation	Date	Results Document	Observations If, any	Done
1.	Bread board model T&E		☐		☐
2.	Bench level		☐		☐
3.	Engineering model		☐		☐
4.	Flight model		☐		☐
5.	OILS		☐		☐
6.	Dis assemble model		☐		☐
7.	Assemble model		☐		☐
8.	Ground segment compatibility		☐		☐
9.	Polarity		☐		☐
10.	Thermo vacuum		☐		☐
11.	Vibration		☐		☐
12.	PSLV compatibility test		☐		☐

Table 10-5: Checklist of Clearances

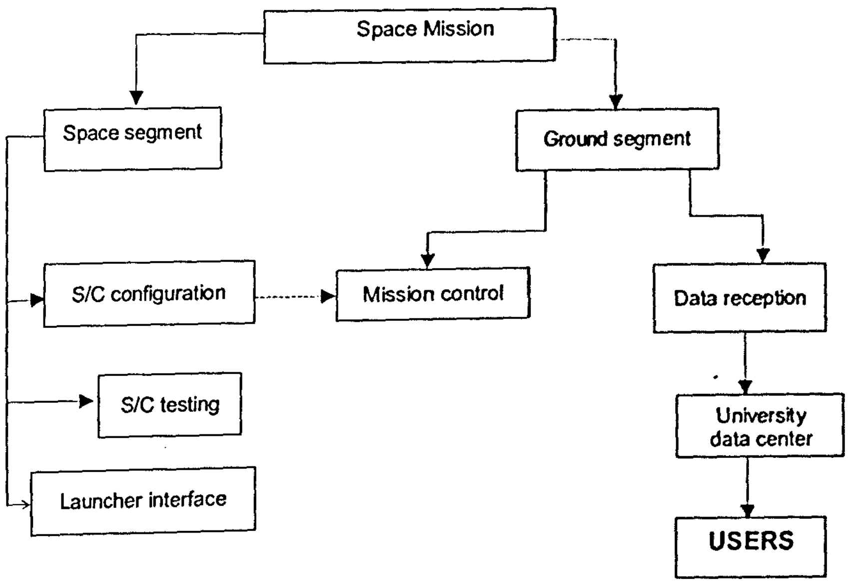
S.No	Clearances	Date	Done
1.	Frequency clearance		☐
2.	Frequency clearance with PSLV		☐
3.	Accommodation clearance with PSLV		☐
4.	Safety Clearance		☐
5.	Material Clearance (Degasing etc)		☐
6.	All committees clearance		☐

Annexure-1 Introduction to different segments of Mission

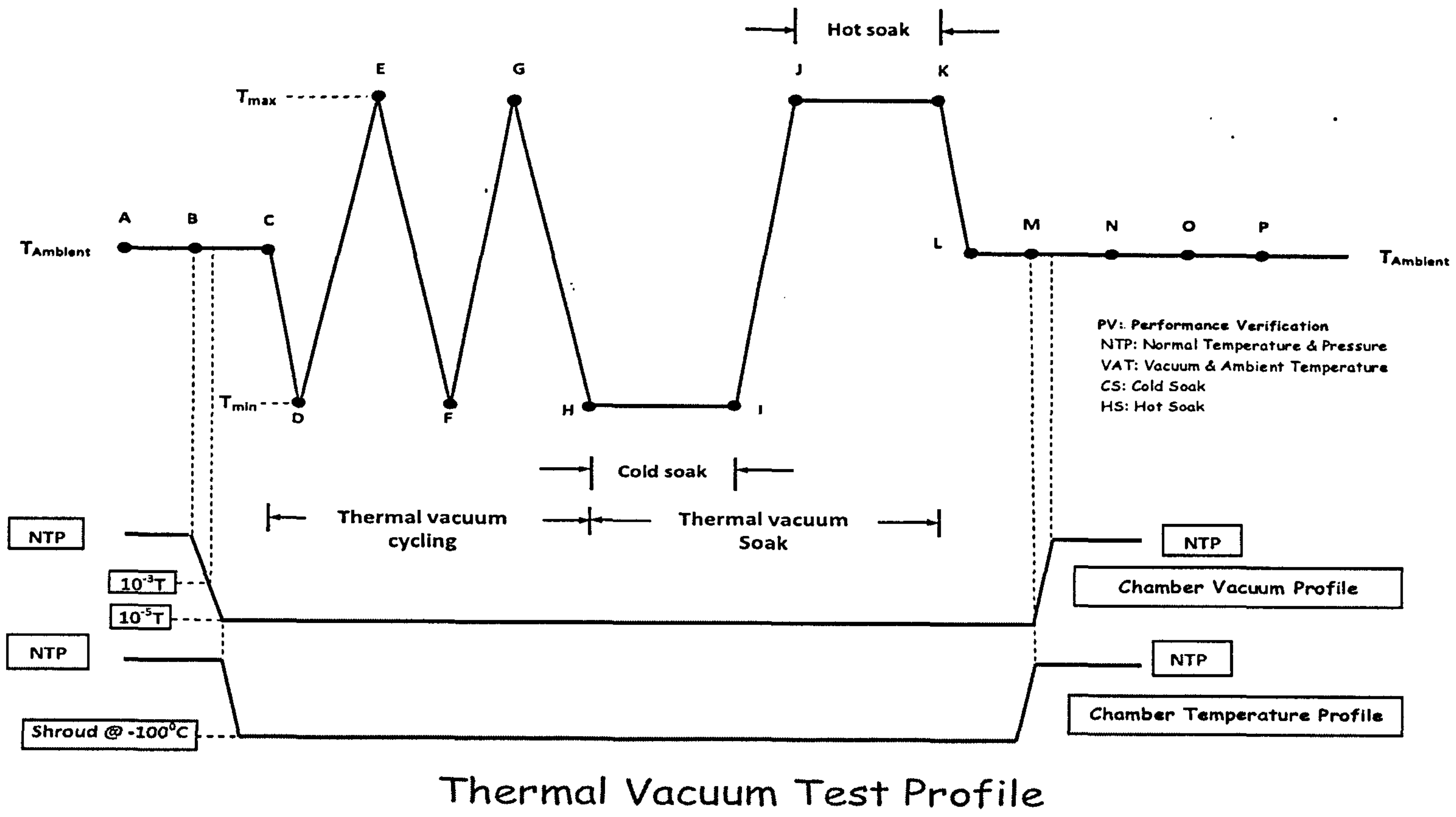
The overall mission elements of the student satellites are essentially the following:

- **The Payloads** shall be designed and developed by Institutions / universities.
- **Spacecraft bus** (will be designed & developed by Universities) that can support the Payload and its structure, Orbit & Attitude control, thermal control, power supply, data compression, data encryption, data formatting, data transmission and storage.
- **Launch vehicle:** All student satellites are planned to be launched with PSLV as an auxiliary satellite.
- **Mission management** by Institutions / universities
- **Ground systems** Designed & developed by Universities with the guidance of ISRO for telecommand, telemetry and Payload data reception. Universities are responsible for processing the received data, making data products at different levels, archival & dissemination of data to other interested universities.

Various segments of typical satellite missions are provided in the figure given below.



Typical Mission elements/segments in space mission



Annexure 2- Typical Thermal profile for Thermovac test

DOCUMENT CONTROL DATA SHEET	
01. Security & Distribution Status	U Unrestricted
02. Projected Utility life	a) 6 Yrs. b) 6 -15 Yrs. c) > 15 Yrs.
03. Report Status (Indicate replacement Of old document, if any)	New
04 Report No.: ISRO-ISAC-TR-1036	Part No. or Vol, No.:
06. Title & Subtitle: GUIDELINES FOR STUDENT SATELLITE PROPOSAL	
07. Contract No.: ~~2462~~	08. Collation (No. of pages): 110
09. Personal Author(s): - None	
10. Affiliation of Author(s) other than ISAC: None	
11. Corporate Author(s): **Programme Management Office, IRS & SSS**	
12. Origination Unit: Division/Group: **IRS-PMO / ISAC**	
13. Date of Submission: **February 2012**	14. No. of References:
Abstract: This document provides the facilities required at university end, support provided by the ISRO, reviews, & tests to be conducted, documents to be prepared etc. To get student satellites proposal in uniform format and information it was decided to bring out a guideline document.	
Keywords/Descriptors: 1. Guidelines 2. Proposal 3. check list	B) Standardized by Bibliographical Control Agency: (To be given by Library) 1. STUDENT SATELLITES 2. SATELLITE GUIDANCE 3.
17. Supplementary Elements: None	

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Programme Director, IRS&SSS

Dr. M. ANNADURAI
... DIRECTOR-IRS & SSS/
...CHANDRAYAAN-2