Preliminary Design Review

Ultra Violet Imaging Telescope (UVIT)

TEST AND CALIBRATION FACILITIES FOR ASTROSAT-UVIT

UVIT-PDR-013-Version 1.0

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Part I : Integration and Calibration Facilities For UVIT

PART II : Storage and Transport of UVIT

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Reference Documents

- FED-STD-209 Airborne Particulate Cleanliness
- MIL-STD-1246C Molecular Contamination
- ISO 14644-1 Classification System for Clean-rooms
- ISO 14644-2 Classification System for Clean-rooms
- MIL-P-27401 Nitrogen purge lines
- GOESN-RTP-197, Handling and Transporting
- GOESN-RTP-198, Handling and Transporting
- ISRO-ISAC-RR-000, Contamination and Handling and Transporting
- FUSE Document FUSE-SAI-301, Contamination
- XMM-OM/MSSL/NT/0022.01, Contamination
- NASA Contractor Report 4740, Contamination
- UVIT-BDR-Test and calibration Facilities - Version 1.0
- AGM-Catalog-03B, Handling and Transporting
- SAE-AS27166 Handling and Transporting
- ASTM-E-1234 Handling and Transporting

PART I

Integration and Calibration Facilities For UVIT

1. Clean-room requirements of UVIT

The UVIT will suffer from performance degradation as a result of contamination of the optical surfaces. Strict control of particulate and molecular contamination is of paramount importance in maintaining the performance of UVIT. Experiences of other space missions clearly show that a molecular contaminant deposition of only 5Å can seriously degrade performance. UV light interacts in complex ways with contaminants and materials that outgas. This results in dramatic increase in deposition rates beyond those rates predicted by using standard molecular transport software based on thermally driven, diffusion, evaporation and condensation process. Therefore, every practical and reasonable attempt possible must be made to reduce molecular and particulate contamination. Efforts as outlined in FUSE, HUT and XMM missions would be made to minimize the risk of contamination (FUSE Document FUSE-SAI-301, XMM-OM/MSSL/NT/0022.01, NASA Contractor Report 4740).

1.1 Quantifying Contamination

1.1.1 Particulate Contamination

There are different clean-room standards set by different organizations for different applications. However, the International Organization for Standardization has evolved a standard for common definition for different classes of clean-rooms. This has been widely accepted internationally, including various space missions. ISO has evolved two standards viz the first ISO 14644-1 devoted to the new ISO Classification System for Clean-rooms and the second ISO 14644-2 devoted to Specification for Testing Clean-rooms to prove continued compliance with ISO 14644-1. The new ISO air cleanliness classification scheme is based on the following general expression

$$C_n = 10^N(0.1/D)^{2.08}$$

Where C_n is the maximum number of particles per m^3 with diameter equal or larger than the considered particle diameter, rounded to the nearest whole number. N the ISO classification number, D the considered particle diameter in microns and finally 0.1 is a constant with the dimension in micron. The following table gives the representative airborne particulate cleanliness classes for clean-rooms and clean-zones.

Classification No. (N)	Maximum concentration limits (particles/m^3 of air) for particles equal to and larger than the considered sizes shown below					
	0.1µm	0.2µm	0.3µm	0.5µm	1.0µm	5.0µm
ISO 1	10	2				
ISO 2	100	24	10	4		
ISO 3	1000	237	102	35	8	
ISO 4	10000	2370	1020	352	83	
ISO 5	100000	23700	10200	3520	832	29
ISO 6	1000000	237000	102000	35200	8320	293
ISO 7				352000	83200	2930
ISO 8				3520000	832000	29300
ISO 9				35200000	8320000	293000

Using the above table, it is possible to specify the standard of cleanliness required for different stages of UVIT integration and calibration.

The scattering caused by particulate contamination is also augmented by scattering caused by mirror micro-roughness. The scattering contribution would be minimized by proper baffle design. Therefore, the scattering budget must contain a prescription on the apportioning between optics and particulate contamination. The optical scattering budget includes scattering due to total integrated scatter (this includes RMS roughness, angular resolved scattering and bi-directional reflectance scattering etc.). The total expected particulate contaminants allowed on the telescopes at the end of their life is 300ppm and this number is based on the experiences from other projects such as XMM, HUT and FUSE.

1.1.2 Molecular Contamination

Molecular contamination levels are quantified by MIL STD 1246C. Molecular contaminant films are referred to as Non-Volatile Residue (NVR), which is defined as the soluble material remaining after evaporation of a volatile liquid or determined by special purpose analytical instruments. NVR is measured in mg/lit (g/cm^3) or µg/cm^2 (mg/0.1 m^2). NVR levels quantified by MIL STD 1246C are specified in Table 2.

Level	NVR (µg/cm^2)	Contamination Thickness (Assumes a density of 1 g/ cm^3)		
		µm	nm	Å
A/100	0.01	0.0001	0.10	1
A/50	0.02	0.0002	0.20	2
A/20	0.05	0.0005	0.50	5

A/10	0.1	0.001	1.00	10
A/5	0.2	0.002	2.00	20
A/2	0.5	0.005	5.00	50
A	1.0	0.01	10.00	100
B	2.0	0.02	20.00	200
C	3.0	0.03	30.00	300
D	4.0	0.04	40.00	400
E	5.0	0.05	50.00	500
F	7.0	0.07	70.00	700
G	10.0	0.10	100.00	1000
H	15.0	0.15	150.00	1500
J	25.0	0.25	250.00	2500

Molecular contamination levels as compared to MIL STD 1246C Cleanliness

The primary effect of Molecular contamination is the wavelength-dependent absorption and/or photopolymerization which is most damaging in UV. ESA have specified a maximum level of molecular contamination of $<10^{-7}$ g cm^{-2} at the end of life (RS-PX-0016 Rev.2).

2. DESIGN BRIEF FOR CLEAN-ROOMS

2.1 PROJECT NEEDS – HVAC (Heating, Ventilation and Air conditioning)

Project needs include air-conditioning of Cleaning room, Telescopic Structure Integration, Telecscopic Structure metrology and Telescopic Integration and calibration rooms generally as per the drawings.

2.1.1 Air-conditioned areas:

Generally as per enclosed heat load summary as follows:

Cleaning room – Normal Air-conditioning having a floor area of 504 sq.ft – False ceiling height 4 m
Telescopic Structure Metrology – Class 100,000 (ISO 8) having a floor area of 992 sq.ft – False ceiling height – 4 m
Telescopic structure Integration – Class 10,000 (ISO 7) having a floor area of 992 sq.ft – False ceiling height – 4 m
Telescopic Integration and calibration – Class 1000 and Class 100 (ISO 6/5) having a floor area of 792 sq.ft – False ceiling height 5 m

2.1.2 <u>Forced ventilated/exhausted Areas:</u>

Toilets
Ultrasonic cleaning room and Machine/tool shop

2.2 BASIS OF DESIGN:

2.21 Outside Design conditions:

Summer	: 35.6 deg. C DB/ 25.6 deg. C WB
Monsoon	: 27.8 deg. C DB/ 25.6 deg. C WB
Winter	: 14.4 deg. C DB/ 12.2 deg. C WB

2.2.2 Inside Design conditions:

: 23 +/- 1.1 deg. C DB & RH 40 +/- 5% for all areas
: 20 +/- 1.1 deg. C DB & RH 25% +/- 5% for Telescope integration and calibration room

2.2.3 Outside air, lighting, occupancy and Equipment load:

Outside air : 5 air change per hour

Lighting - 2 watts/sq.ft

Equipment Load:
Cleaning room – 12 KW
Telescopic structure metrology room – 8 KW
Telescopic structure integration room – 15 KW
Telescopic integration and calibration – 6 KW

Diversity on equipment load – 0.8

2.2.4 Power supply:

415 V, 3 phase 4 wire 50 cycles AC/ 230 V, 1 phase 2 wire 50 cycles AC
Uninterrupted power supply is required for the DDC panels pertaining to Building Automation system.

2.2.5 Exposed roof insulation and windows:

All windows are considered with special tinted glass, blinds and exposed roof is considered with 13 mm thick nitrile rubber insulation under the deck

2.2.6 Duration of operation:

12 hours/day and round the clock occasionally when there is a continuous activity

2.2.7 Noise level:

A noise level of around 52 to 55 dBA inside the conditioned area is possible to be obtained.

2.3. AIRCONDITIONING SYSTEM CAPACITY:

Based on the heat load calculations, the peak cooling load works out to 41 TR and considering certain diversity and surplus capacities, the air-conditioning systems are as follows:

3 nos. 30 TR Roof top air-cooled chillers for cooling ethylene glycol in which 1 no acts as a standby.

These chillers are housed on the terrace of the building in an open area along with chilled brine circulating pump sets.

Each chiller is with multiple scroll type compressors which will perform efficiently during part load conditions.

Ultrasonic cleaning rooms are provided with supply and exhaust system. The fume hood exhaust will be done by the exhaust fan with activated carbon filters to dilute the odours of acetone if any.

Toilets are provided with forced exhaust system.

Special precaution is taken to arrest vibration getting transmitted from the mechanical system. Airhandling units are provided with special isolators, ducts are supported on rubber molded saddles.

2.4.DETAILS OF EQUIPMENTS/MATERIALS:

2.4.1 SCROLL TYPE CHILLERS AIR-COOLED CHILLERS:

Air-cooled scroll type brine chilling machines with R 22 refrigerant each having a capacity of 30 TR. Three chillers are provided in which one acts as a standby.

Multiple compressors offer better part load efficiency will facilitate higher flexibility in operation.

The chiller is complete with microprocessor type plant manager enabling easy hooking up with building automation system.

Low relative humidity levels to be maintained within the conditioned areas calls for a low temperature cooling medium having a temperature of minus 10 deg. C. As such ethylene glycol is used as a cooling medium

2.4.2 PUMPSETS:

Single stage centrifugal coupled pumpsets with mechanical seals and bronze impellers are provided for the chilled water circulation system. 3 nos. pump sets are provided in which one number will act as a standby. The pumpsets are mounted on spring mounts for vibration isolation.

2.4.3 AIRHANDLING UNITS/AIR DISTRIBUTION SYSTEM:

Floor mounted horizontal double skin (50 mm thick) airhandling units with back ward curved centrifugal fans are provided for all areas except cleaning room which is of vertical type. The air handling units are with supply and return air fans. Cleaning room has a vertical type unit with only supply air fan. Supply and return air fans will enable maintenance of required positive pressure within the conditioned area and will also facilitate sharing of the duct and system pressure drops resulting in a lower speed. This helps in achieving lower vibration levels. The fans are controlled by variable speed drives taking pressure signals generated due to the chocking of filters.

Airhandling units are provided with limit switchs on the door to switch off the blower incase the door is opened when the blower is in operation. Marine lights are also envisaged inside the airhandling units. Each airhandling unit is provided with outlet damper duly motorised. There will be separate fire dampers at the supply and return air circuits. The cooling coils are for ethylene glycol medium.

Each airhandling unit is with twin motors (one number to act as a standby). Telescopic integration and calibration room is provided with two nos. airhandling units which will offer certain flexibility in operation and can be operated with a single unit for maintaining class 1000 conditions.

Fine filters will be housed inside the airhandling units itself, whereas the HEPA filters will be installed at the supply air diffuser plenums installed within the conditioned area.

Fan filter units will be installed over the optical tables for maintaining class 100 conditions. These fan filter units will be installed at 3000 mm from the false floor level. A shroud has to be installed around the fan filter units upto a height of 2100 mm from the false floor level leaving a space of 1100 mm above the table the table height being 1000 mm all from the false flooring level.

Return air in the clean room areas are collected through return air riser which is a part of the clean room partition system. The entire clean room area will have walkable false ceiling and wall panels.

For the ultrasonic clean rooms, forced ventilation areas, separate supply and exhaust fans of centrifugal type is contemplated. The fume hood will be connected to the exhaust ducting. The exhaust ducting will be epoxy coated and will have an activated carbon filter to remove acetone odour. Toilets are provided with an exhaust fan.

Electrical strip heater package is envisaged for close monitoring of the relative humidity within the conditioned area.

Air handling units are hooked with fire detection system to switch off the same incase of fire. Staircase pressurization will come on incase of fire.

Fire agency shall be hooking the fire detection system to the airhandling units electrical panels so that the MCCB is tripped incase fire is sensed. This will be over and above the tripping of the airhandling units from the Building automation system pertaining to HVAC.

2.4.4 AIR DISTRIBUTION AND CHILLED WATER PIPING AND INSULATION:

Cooled and dehumidified air obtained from the airhandling units is taken to the conditioned areas by means of GSS ducting running above the walkable false ceiling and distribution is by means of diffusers generally as per the drawings. Supply diffuser plenums will have HEPA filters. Return air will be by return air ducting. The supply and return air ducts are duly insulated using nitrile rubber insulation.

Ducts are fabricated using aluminium sheets with specifications better than IS 655. Factory made supports for air plenums are proposed. The diffuser plenum will be connected to the main ducting using insulated flexible ducts.
The air terminals are of powder coated aluminium. Fire dampers, volume control damper and sound attenuators are envisaged. Fire dampers are of motorised type provided in the supply and return air ducting entering the AHU room that will close incase fire is sensed by the fire detection system.

2.4.5 ULPA fan filter units with variable speed control are provided for the class 100 area.

Chilled brine circulation is by means of black steel pipes with butterfly valves, balancing valves. Control is by means of three way motorised valves. The pipe insulation is done with synthetic foam finished with FRP.

Automatic expansion tank hooked to a hydropneumatic system is proposed. Automatic air vents are also envisaged. Motorised shut off valves are provided at the outlet of the evaporator water circuits. The exposed roof is provided with underdeck insulation using synthetic foam.

2. 5. EHS STANDARDS

Environmental, Health and Safety Practices are strictly followed in the scope of work. Materials, which spread fire, are not used in the conditioned area.

2.6. Building automation system have the following facility:

- facilitates remote switching on/off of various equipments
- has facility for remote adjustment of set points with levels of control
- facilitates timed and event related functioning and programming of equipments
- has run time equalisation and sequencing of equipments
- can create Centralised alarm and maintenance schedules
- acilitates Trip indication status
- has Trouble shooting history
- has Complete P & I capability
- can Hook with fire management system and other services
- can do Power and capacity evaluation of various equipments

2.7. ELECTRICAL REQUIREMENTS:

1. Necessary HT ,LT panels and transformer have been installed. The statutory bodies have sanctioned the necessary power for the additional load.
2. Two numbers 320KVA diesel generators have been ordered with 100% redundancy to ensure that there is no shut down.
3. Three numbers of 20KVA UPS have been ordered to provide clean supply for the sensitive equipment.
4. Stringent ESD requirements have been met with 12Nos earth pits.

3 Clean-room activities

Clean-room	Area Sq.ft	Equipment	Activity
Cleaning Area	504	Chemical ultrasonic cleaner, Water ultrasonic cleaner, Machine shop, Drying area	Cleaning of structural parts, small mechanical works
Class-100000 (ISO8)	992	Change room, air shower, Cleaning enclosure, clean tables, clean-room tools, metrology equipment	Structure metrology, clean-room machining, storage
Class-10000 (ISO7)	992	Air shower, large vacuum facility, clean-room tables, cleaning enclosure, metrology equipment	Structure integration and metrology
Class-1000 (ISO6)	792	Change room, air shower, air lock, class-100 enclosure (9m□2m), cleaning enclosure, clean optical tables, interferometer etc.,	Telescope integration, testing of UVIT in visible/NUV, vacuum tests on UVIT

4 Clean-room Procedures

We will be adopting the following clean-room procedures that have been followed by other space missions such as FUSE, HUT etc. and also ISO 14664-1 standards.

1. Unidirectional airflow clean rooms for telescope integration and testing.
2. Strict control of particulate and molecular contamination and parameters such as temperature, humidity (< 15 % at telescope integration room) and pressure.
3. Facility to monitor temperature, humidity, pressure and also to monitor particulate and molecular contaminants.
4. Restrictions on the maximum number of people permitted in the clean room.
5. All the personnel shall wear ISO 1/2 specified garments including hood. These are low nonvolatile residue (should not deposit more than 0.1mg/sq. foot molecular contamination) gloves, jumpsuits and hoods.
6. Clean-room maintenance/cleaning methods, frequency, prohibition on using contaminant generating cleaning agents or methods.

7. Use of HEPA filter vented vacuum cleaners, clean-room certified tools etc. for the facility.
8. A training program shall be established for all the personnel in clean room procedures based on other space missions.

3. Status Report

3.1 Civil Works

Work	Status	Expected date of Completion
External Electricals	90% Completed	30 March 2006
Internal Electricals	90% Completed	30 March 2006
VDF and Self leveling Epoxy		April 2006
All Civil works		April 2006

3.2 Clean-room works

Work	Status	Expected date of completion
Chillers, AHUs, Fan Filters, BAS, panels etc..	At site	
Ducting	80% Completed	30 March 2006
Panel installation	Panels Procured	April 2006
Building Automation System	Work in progress	May 2006
Fire Alarm, Access Control, CCTV etc	Work in Progress	June 2006
Commissioning of Chillers, AHU etc..		May 2006
Clean-room validation		June-July 2006

3.3 Test Equipment

Equipment	Status	Installation
Small vacuum tank, monochromator, source etc. for component tests	At class 10000 clean-room	Experiments are in progress
Reflectometer		Contamination studies in progress
Fizeau Interferometer (Zygo)		Installed and is working fine
18” reference flat	Arrived	
Large vacuum tank	Tendering process is in progress	June 2007
Contamination monitoring equipment such as particle counters, QCM, RGA etc.	Order to be placed	August 2006
Ultrasonic cleaners, fume hoods etc.	Order to be placed	August 2006

Part II
Storage, Packaging and Transport of UVIT

II.1 Introduction

The purpose of this document is to provide safe storage, packaging and transport of UVIT. It is extremely sensitive to molecular contamination. It must be treated with extreme care during all stages of assembly, testing and finally delivery to ISRO. The following procedures need to be followed for safe handling of UVIT with regard to ESD, shock and vibration.

II.2 General Precautions

1. Do not touch the instruments with bare skin – used approved, non-powdered, nitrile or latex gloves and always maintain a firm grip.
2. Use proper ESD handling procedures.
3. Shock and vibrations to be avoided. Vibration isolated (pneumatic isolators)
4. Purged by ultra-clean dry nitrogen (MIL-P-27401) with breather valves
5. Temperature to be maintained between 10deg C and 30deg C.
6. RH of 0% with a tolerance of +/-5% (Humidity Indicators).
7. Double Containers for better contamination control
8. Witness coupons for contamination monitoring
9. Container Handling Protocols

II.3 Quality Assurance

1. Quality assurance surveillance and monitoring of storage conditions and packaging should be in place.
2. Quality assurance group to evolve guidelines during the entire process of procurement of individual components, their cleaning, storage, assembly, test and calibration, packaging, transport etc.
3. This group is responsible for all the issues with contamination control protocols and their strict adherence.
4. Every process need to be verified and certified by quality assurance group.

II.4 Contamination control during storage and handling

Necessary cleanliness protocols have to be followed for Storage and handling of UVIT either in component levels or in integrated system level so that the instrument performance integrity is maintained as per design specifications. The following need to be followed.

1. All the components are covered with ESD-safe covers or shroud.

2. ESD-safe protective covers should be in place during all handling, packaging, storage and transportation operations to prevent damage to the entrance apertures of the instruments and also molecular contamination.
3. Stored in a sealed containers purged with dry nitrogen.
4. Periodic inspections to be done as per the following table (NASA-JSC-SN-C-0005, ISRO-ISAC-ASTROSAT-RR-000)

Inspection Level	Incident Light Level (foot candles)	Observation distance (ft)	Remarks
Visibly clean (VC)	≥ 50	5 — 10	(b), (c), (e)
Visibly clean + Sensitive (VCS)	≥ 50	2 — 4	(b), (c), (e)
Visibly clean + Highly Sensitive (VCHS)	≥ 100	0.5 —1.5	(c), (d)
Visibly Clean + Highly Sensitive + UV light (VCHS+UV)		1 — 3	Extreme caution for UVIT optics

a) One foot-candle (lumens per square foot) is equivalent to 10.76 lumens per square meter
b) Cleaning is required if the surface in question does not meet VC under the specified incident light and observation distance conditions.
c) Exposed and accessible surfaces only.
d) Initial cleaning is mandatory; Note b) applies thereafter.
e) Areas of suspected contamination may be examined at distances closer than specified for final verification.

5. Witness samples are monitored for possible particulate and molecular contamination at specified regular intervals.

II.5 ESD Precautions

1. UVIT or its components must be grounded properly during long-term or temporary storage.
2. Ensure that proper grounds are affixed to the instruments prior to any moving or lifting operations.
3. The operator must also be properly grounded before handling the instruments.
4. Wrist straps should be in contact with the operator’s skin, not with the outside of the gloves.
5. Constant-monitoring wrist-straps with audible alarms are preferred.
6. Avoid lifting and handling operations if the relative humidity is below 30%, or take extra ESD-safety precautions (such as redundant ground-clips) if such handling unavoidable.

II.6 Nitrogen purge requirements

1. All plumbing lines, regulators, valves etc. in the laboratory shall be internally electro-polished to meet class-1 requirements.
2. Use only liquid nitrogen boil-off (0.5μ filtering) or class-c or better (MIL-P-27401) research grade bottled nitrogen for purging.
3. Use ultra-high-purity PFA Teflon tubing (400HP or better) where flexible tubing is required.
4. Storage and shipping-container purge fittings and tubing will be to meet class-1 standards.
5. Gaseous nitrogen of MIL-P-27401 standard will flow at a rate of 1—10SCFH.
6. Place the covered/baggaged instrument into the container and secure in place.
7. Open the pressure relief valve on the shipping container.
8. Close the container lid, and allow the purge to continue for at least two hours prior to tight sealing.
9. Remove the nitrogen lines and seal the purge nipple and pressure relief valve.

II.7 Additional precautions

1. UVIT must be stored within the prescribed temperature limits (TBD).
2. No vacuum storage except in orbit.
3. UVIT should be under clean nitrogen purge environment.
4. Do not subject UVIT or any of its components to large shocks and vibration.
5. Do not bump, drop or slide the shipping containers.
6. Use highly visible “Fragile” stickers on the containers.
7. A full comprehensive performance test to be done on the instrument periodically (TBD) if the instrument is stored for long periods.
8. Check the witness coupons for possible contamination at regular intervals
9. Certification of all the processes from the “Quality Assurance Group”.