The following packet is a contamination control training intended for personnel handling or coming to contact with LRO flight hardware. The training will be posted on www.lrocleanroomtraining.org. There is a sign in sheet, followed by a power point presentation on the attached slides, and a 20 question test at the end of the slides on the material presented.

Test results will be emailed to LRO's Contamination Control Rachel Rivera/NASA GSFC Code 546.

The website is intended for use by LRO, instrument vendors, KSC personnel, and launch vehicle provider personnel coming into contact with LRO.

National Aeronautics and Space Administration

LRO - Lunar Reconnaissance Orbiter

SIGN-IN SHEET

PLEASE SIGN IN

Fill out the following information to begin

First Name

Last Name

Company

Job Function

US Citizen? Yes or No

Email Address

Confirm Email Address

CONTINUE >

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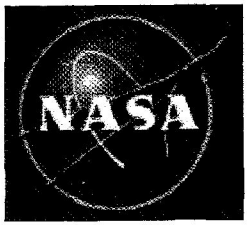
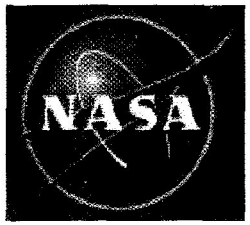


Lunar Reconnaissance Orbiter Contamination Sensitivity Training



Training Objectives

- A contamination control program has been established in order to prevent performance degradation of LRO flight hardware.
- As part of this program, this training is being implemented to familiarize personnel, coming into contact with LRO hardware, what its contamination sensitivities are and what can be done by all to maintain its cleanliness levels.
- A test will be given at the end of this training as a means to ensure personnel have had exposure to this information and can demonstrate enough understanding to be able to follow through with proper etiquette near flight hardware.

Introduction to Contamination Requirements

- **There are 2 types of contamination requirements:**
  - Surface cleanliness levels:
    - **Molecular requirements-** films, greases, skin oils
    - **Particulate requirements-** dust, debris, skin cells
  - Outgassing requirements:
    - Bakeouts are required in order to meet molecular outgassing flux levels (individual hardware requirements vary)

Flight Hardware Delivery Requirements:
- Level 450 A/2
- Outgassing rates

- Not all hardware is sensitive to contamination, however all hardware still possess contamination requirements in order to avoid cross-contamination due to their close proximity to sensitive hardware components.
- Cleanliness standards must be maintained throughout the entire program due to the difficulty in the cleaning of delicate materials, inaccessible cavities, and/or hard to clean contamination.

Hardware Description: 3 Groups

There are 3 groups of hardware: Critical Surfaces, General Flight Hardware, and cleanroom Ground Support Equipment (GSE).

Critical Surfaces

- LAMP-UV instrument
- LROC-optics
- DIVINER-optics
- LOLA-laser
- CRaTER-detector
- Radiators
  - On the bus
  - Instruments
- Laser Ranging
- Course Sun Sensors
- Star Trackers-optics
- Propulsion Lines

General Flight Hardware

- S/C Structural Bus
- Solar Arrays
- High Gain Antenna
- Propulsion Systems
- Electronic boxes
- Omni Antennas
- LEND
- Mini-RF
- GBK MLI

Cleanroom GSE

- Purge Carts & Lines
- Slings/Fixtures
- Scaffolding
- Tools
- Cameras
- Procedures/ Paperwork
- Chemicals, tapes
- Transportation Cases
- Connectors
- Cables, wires, etc.
- Test Equipment

Contamination Critical Surfaces

Critical Surfaces

- LAMP-UV instrument
- LROC-optics
- DIVINER-optics
- LOLA-laser
- CRaTER-detector
- Radiators
  - On the bus
  - Instruments
- Laser Ranging
- Course Sun Sensors
- Star Trackers-optics
- Internal Prop Lines

Critical Surfaces drive contamination requirements

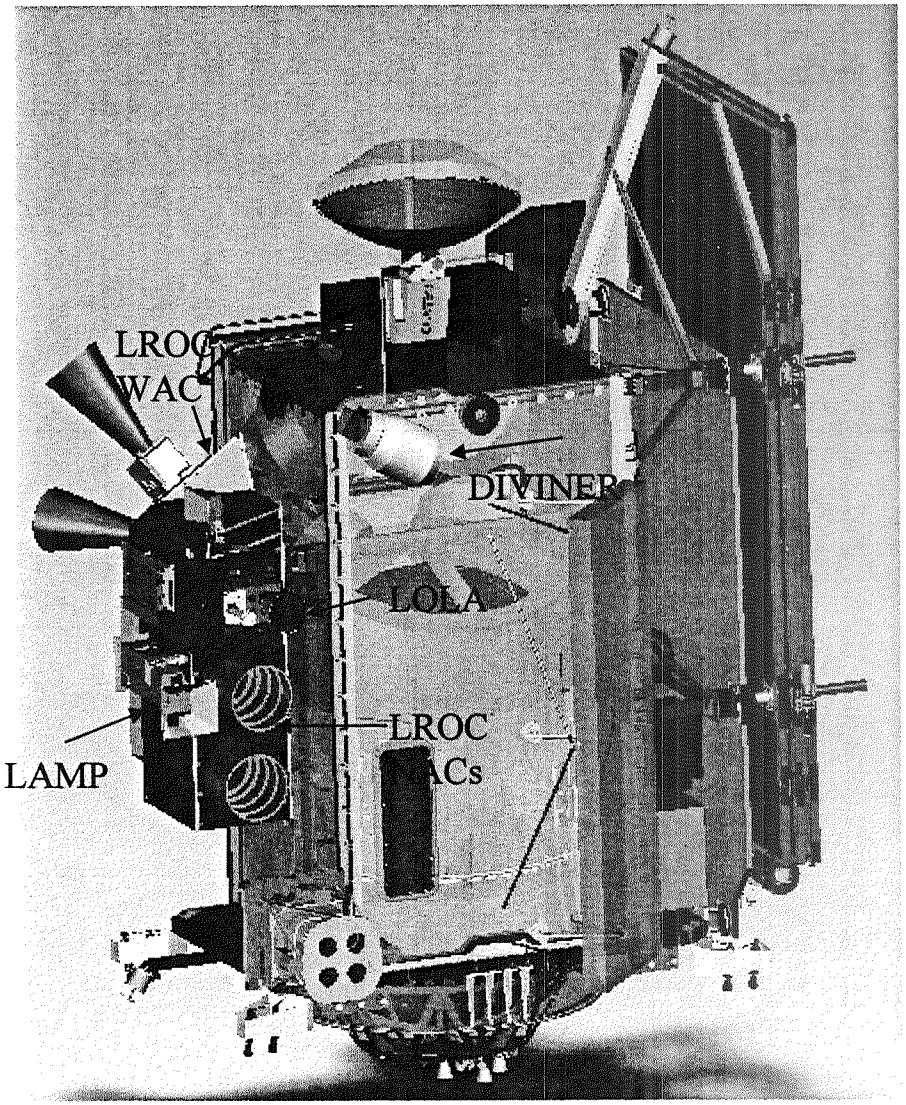
Contamination Critical Surfaces: Instruments

Scientific instruments have very sensitive components. Covers are used to protect optics and detectors during processing.

Nitrogen purges are also used to protect sensitive components from humidity and contamination.

- –LAMP - uses deployable covers; purges
- –LROC - optics have covers; purges
- –DIVINER - uses covers; bagged purge
- –LOLA – uses a soft cover and a laser beam stop; purges
- –CRaTER –sensor unit cover; purges

Regardless of purges and covers, instruments are always treated with optimal care



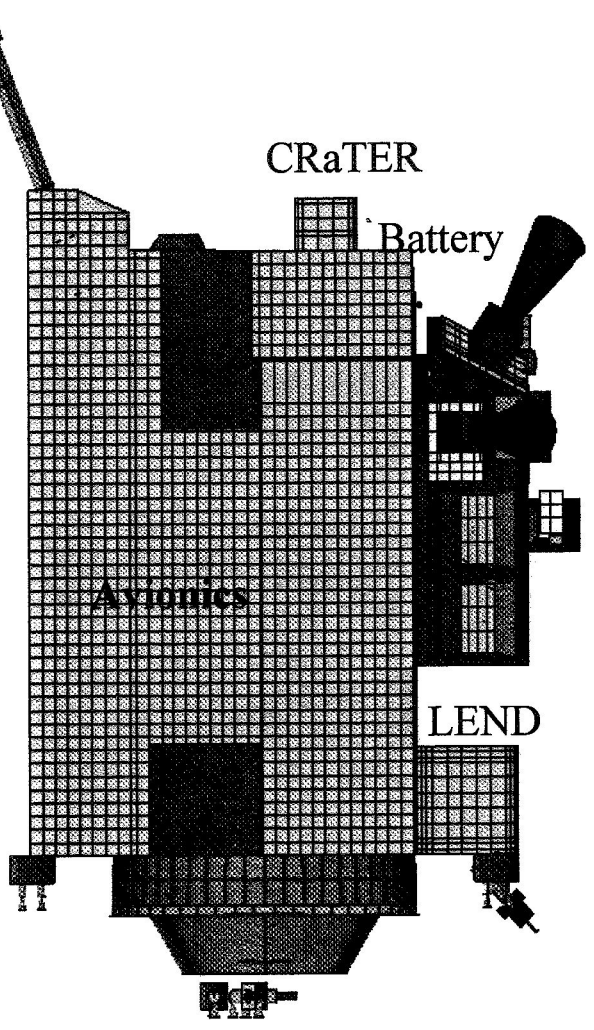
Contamination Critical Surfaces: Instruments (Cont.)

All Critical Instruments have a minimum:

- **External** Surface Cleanliness Requirement: Level 450A/2
- **Internal** Surface Cleanliness Requirement: Vary depending on instrument and are usually more stringent than external requirements
- **Cleanroom** Processing Requirement: Class 10,000

All LRO Flight Hardware and any GSE coming into direct contact with LRO Flight Hardware must maintain a Level 450 A/2 in order to maintain instrument cleanliness level requirements

Contamination Critical Surfaces: Radiators

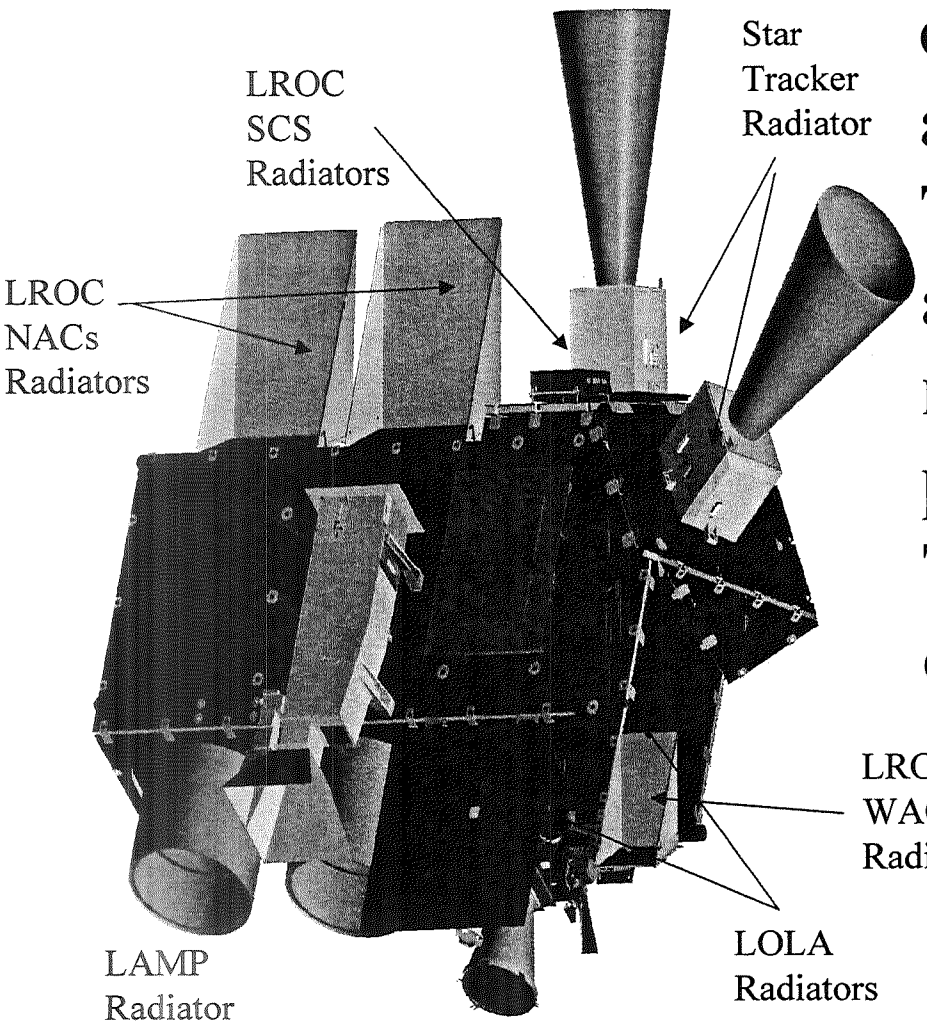


The Avionics Panel, Battery, LEND, and CRaTER Radiators are made of Indium Tin Oxide Coated Optical Surface Reflectors.

These surfaces are contamination sensitive.

5 mil ITO coated OSRs Battery; Avionics; LEND; CRaTER

Contamination Critical Surfaces: Radiators (Cont.)



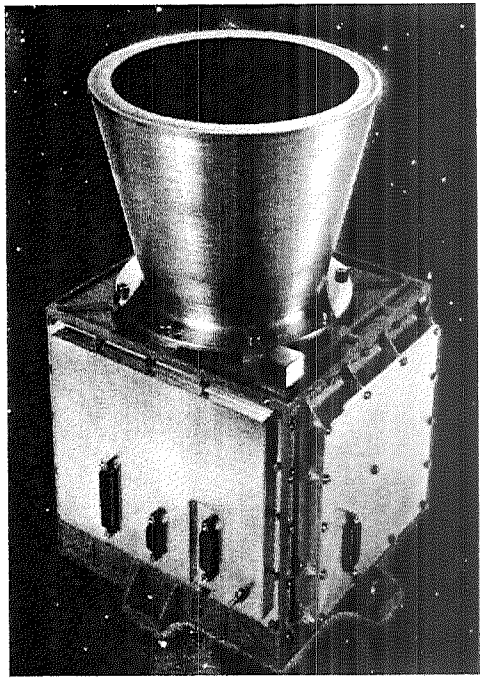
These radiators are thermal coated with NS43C. These are "No Touch" surfaces. They are not easily cleaned and can easily particulate if mishandled. Adhesive are not permitted on NS43C surfaces. This coating is sensitive to contamination.

Other radiator surfaces with this coating, but not shown here are: the CSS mount, SAS and HGAS Actuators, and Feed Horn

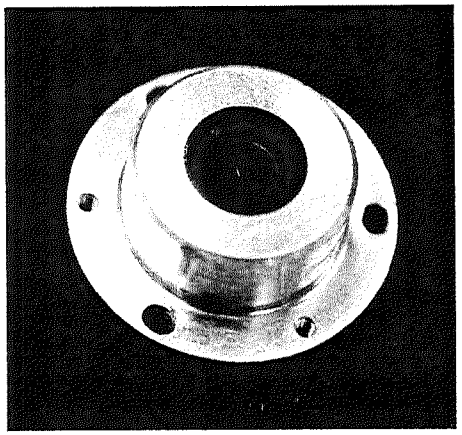
Contamination Critical Surfaces: Bus Module

Other Critical Surfaces with Contamination Concerns are:

- Laser Ranging
- Coarse Sun Sensors
- Star Trackers
- Internal Propulsion Lines



Star Trackers



Coarse Sun Sensors

General Flight Hardware

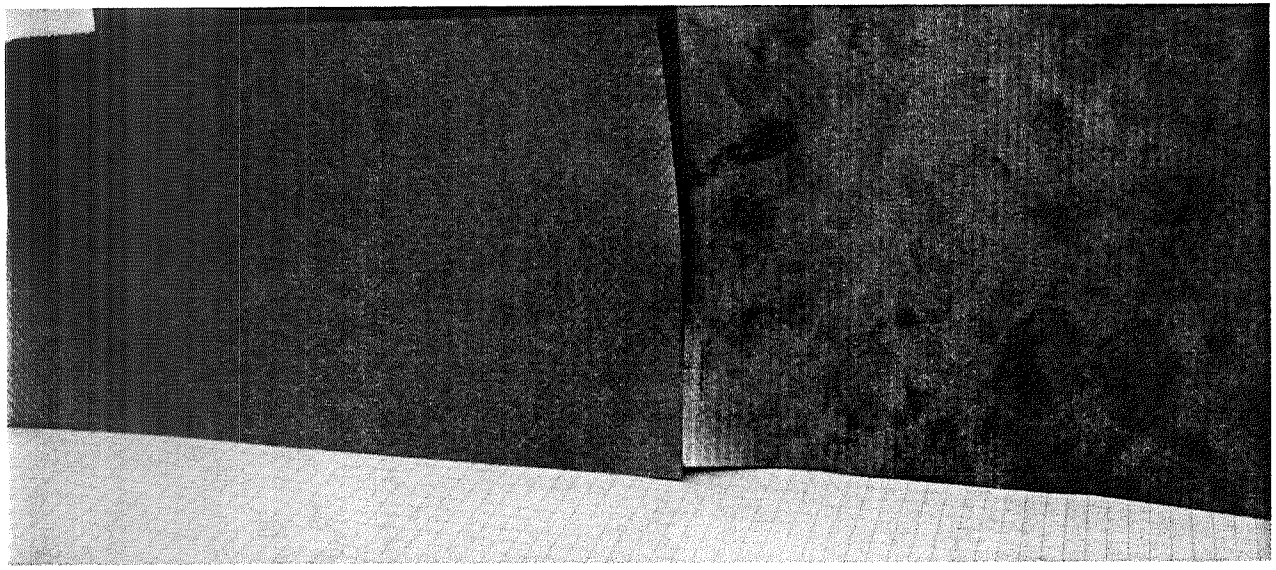
General Flight Hardware
• S/C Structural Bus
• Solar Arrays
• High Gain Antenna
• Propulsion Systems
• Electronic boxes
• Omni Antennas
• LEND
• Mini-RF
• GBK MLI

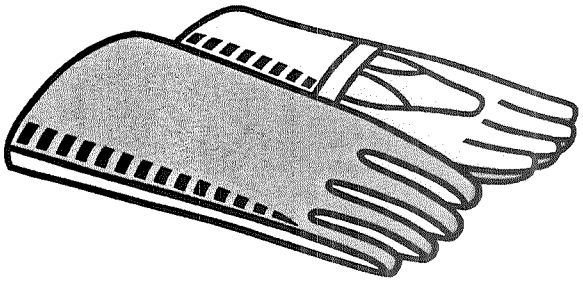
General flight hardware still have contamination requirements and even some contamination sensitivities

General Flight Hardware

- Not all flight hardware is contamination sensitive, however all must meet the contamination levels that are needed for the instruments and critical surfaces to meet their contamination requirements.
- Extra precautions should be taken with the following General Flight Hardware:
  - Solar Array: Solar Cells and RM-400 Thermal Coated Back Side
  - HGA and Omnis: Thermal Coated Surfaces
  - Germanium Black Kapton MLI

Wear Gloves at All Times





Comparison of normal GBK to that of mishandled GBK

Cleanroom GSE

Cleanroom GSE
• Purge Carts & Lines • Slings/Fixtures • Scaffolding • Tools • Cameras • Procedures/ Paperwork • Chemicals, tapes • Transportation Cases • Connectors • Cables, wires, etc. • Test Equipment

All GSE entering cleanrooms must be cleaned and cleanroom compatible

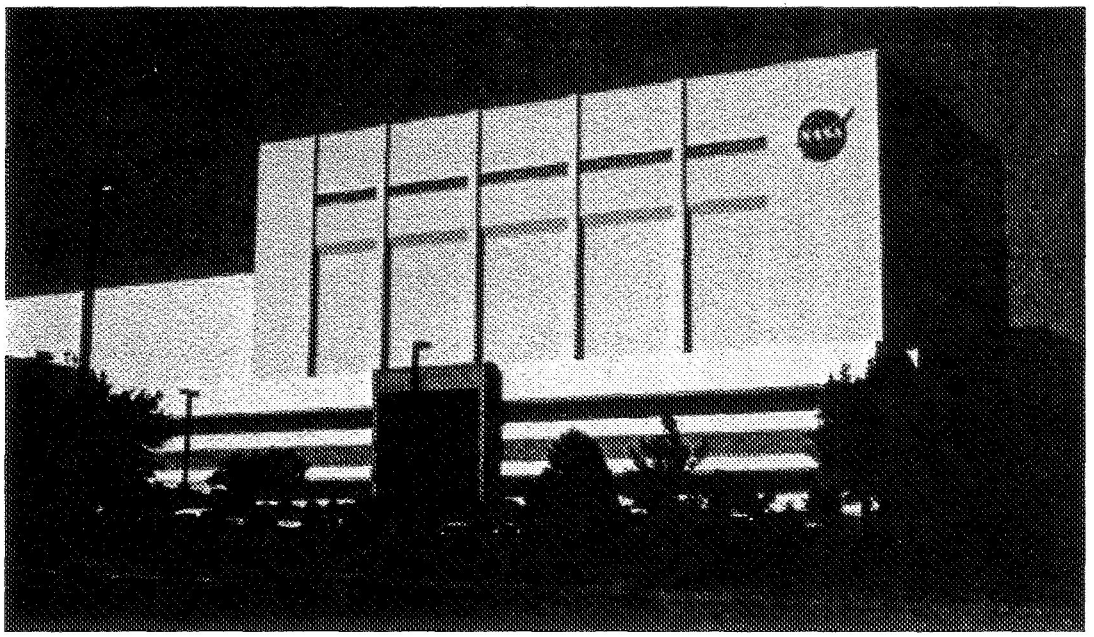
Most GSE entering TVAC with flight H/W should get baked-out

Cleanroom GSE

- Cleanroom GSE supports the ground processing of LRO
- All GSE coming in direct contact with LRO Flight Hardware must be cleaned to the requirements of the flight hardware [450A/2]
- General GSE not coming into contact with flight hardware have a Cleanliness Requirement of Visibly Clean-Highly Sensitive (VC-HS)
- Wrist straps must be cleaned daily
- Purge Carts and Purge Lines: be aware of these lines and stay clear of the purge cart

I&T Processing

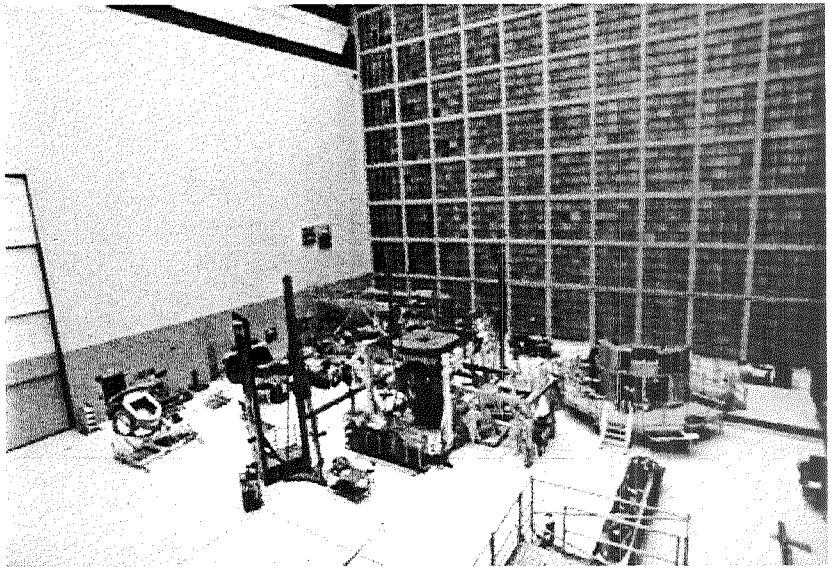
- The LRO I&T processing will begin in the Building 7/10/15/29 complex and associated cleanroom [SSDIF] and Spot-Tents
- Hardware Cleanliness Requirement: Level 450A/2
- Cleanroom Requirement: Class 10,000
  - Personnel gowning requirements
- Purge Requirements: continuous Grade C at inlet to purge cart
  - Continuous GN2 purge required for CRaTER, LAMP, LROC, LOLA
- Restrictions
  - Manloading restrictions
  - ESD
  - Silicone Adhesives

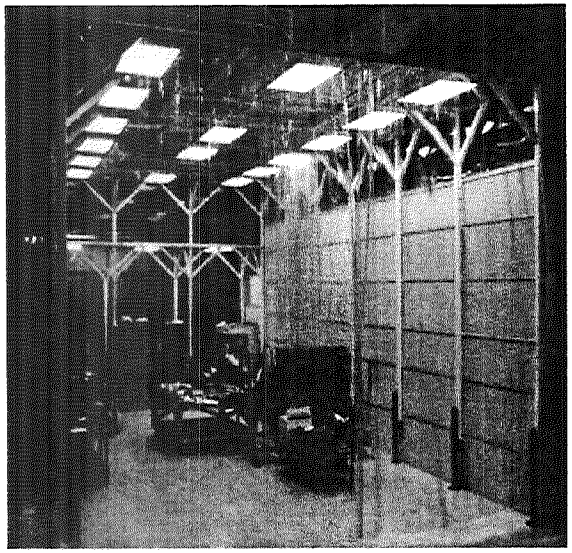


GSFC Facilities in Bldgs. 7/10/15/29

SSDIF Building 29

Class 10,000
Temperature/Humidity Control
Full Cleanroom attire
Precision-Clean Room located in Room S126





SPOT Tents
Class 10,000
Temperature/Humidity Control in Highbay
Full Cleanroom attire

Facility Controls

- All equipment shall be cleaned before entering any cleanroom or cleantent
  - This includes GSE, ladders, scaffolds, dollies, tools
  - A precision cleaning area shall be provided
    - In front of an I&T area
    - Or in the SSDIF Pre-Clean room B.29/S126
  - Objects are to brought to the Pre-Clean room 2-3 days ahead of time [if not, a 1st come, 1st serve basis will be implemented], and a work out order form should be filled out. Items will be cleaned and double bagged.
  - Before entering the clean area remove the outer bag in the anteroom and remove the inner bag in the cleanroom/cleantent.
  - Large items needing cleaning should be scheduled well ahead of time and coordinated with Contamination Control.
  - Emergency needs can be handled, but don't abuse the privilege
  - **NO LAST MINUTE CLEANING PLEASE!**

- Fill out a ManTech WOAs for all cleaning work needed [see next slide]
- **Cleanroom paper** must be used for all WOAs and papers entering a clean area
- Materials brought into the cleanroom shall be cleanroom compatible, if uncertain, contact Contamination Control
- Cleanroom doors and cleantent entrances should not be opened unless all hardware in the room/tent is in a safe configuration

ManTech Work Order for Cleanings

Fill out all sections with an asterisk

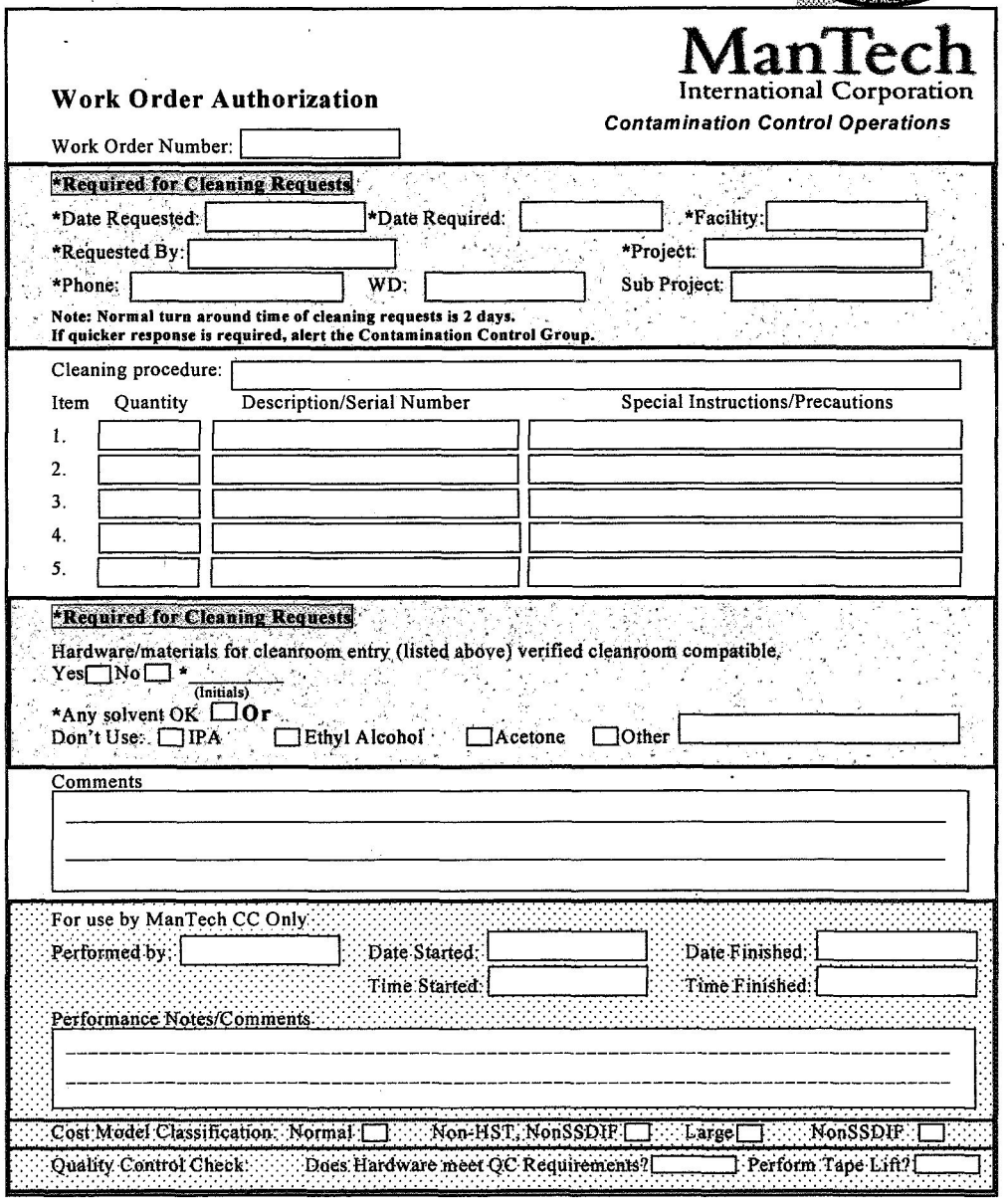
Itemize hardware & cleaning procedures

Fill out all sections with an asterisk. Initial where indicated. **Work will not be completed unless this section is filled out and initialed by requestor.**

Misc Work to be completed not listed above

Do Not Use this Section

Precision-Clean Room Ext. 6-0952



ManTech
International Corporation
Contamination Control Operations

Work Order Authorization

Work Order Number:

***Required for Cleaning Requests**

*Date Requested: *Date Required: *Facility:

*Requested By: *Project:

*Phone: WD: Sub Project:

Note: Normal turn around time of cleaning requests is 2 days.
If quicker response is required, alert the Contamination Control Group.

Cleaning procedure:

Item	Quantity	Description/Serial Number	Special Instructions/Precautions
1.			
2.			
3.			
4.			
5.			

***Required for Cleaning Requests**

Hardware/materials for cleanroom entry (listed above) verified cleanroom compatible.
Yes ☐ No ☐ * _____ (Initials)

*Any solvent OK ☐ **Or**
Don't Use: ☐ IPA ☐ Ethyl Alcohol ☐ Acetone ☐ Other

Comments

For use by ManTech CC Only

Performed by: Date Started: Date Finished:

Time Started: Time Finished:

Performance Notes/Comments

Cost Model Classification: Normal ☐ Non-HST, NonSSDIF ☐ Large ☐ NonSSDIF ☐

Quality Control Check: Does Hardware meet QC Requirements? ☐ Perform Tape Lift? ☐

Personnel Controls

The Big Change

- Now is the time to transition from manufactured part to spaceflight hardware
- Previous standards are no longer applicable
- Rules will be enforced
- Not all mistakes are recoverable – be diligent

Personnel Responsibilities

You are responsible for:

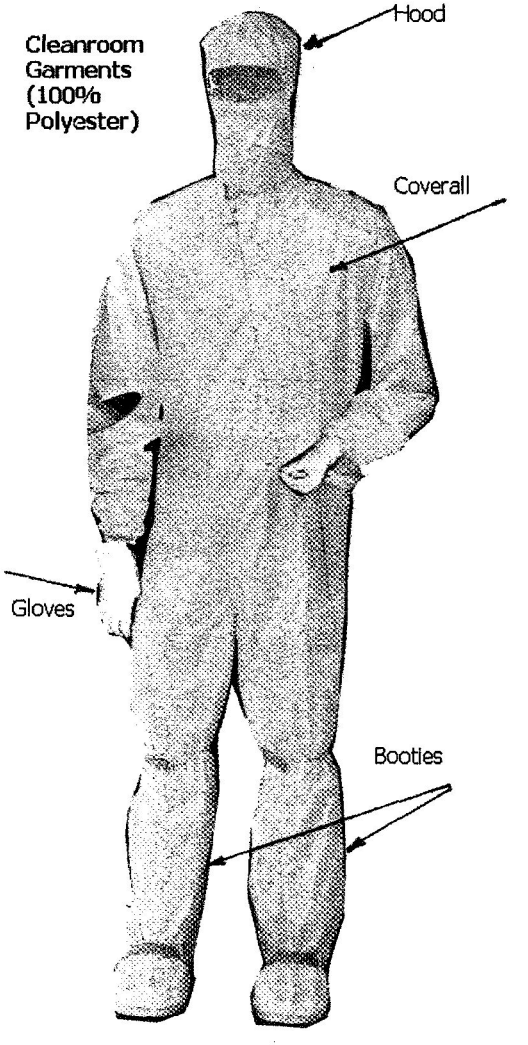
- The contamination you generate
- Following proper procedures and guidelines
- Becoming familiar with new procedures
- Any items you bring near the hardware
- Keeping co-workers accountable for their actions

Personnel Control Reminders

- A person motionless, sitting or standing, will generate 100,000 particles > 0.3 micron in diameter per minute.
- A person with arms, head, and body in motion will generate 1,000,000 particles > 0.3 micron in diameter per minute.
- A person walking at 2 mph generates 5,000,000 particles > 0.3 micron per minute.
- Particles that reside on a surface for a long period of time are harder to clean off.
- Dust collects even within cleanrooms
- Fingerprints can not be completely removed by an alcohol wipe, and on many materials can etch the surface causing permanent changes to the surface properties.
- No make-up, perfume, or after shave are allowed in the clean area
- PEOPLE ARE DIRTY

Cleanroom Requirements and Access

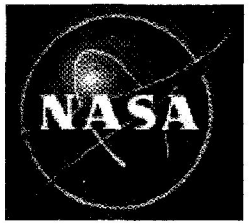
- Largest source of contamination within cleanroom is generated by personnel working in the facility
- Garment Requirements
  - In order of donning garments: Hood, Bunny Suit, Booties, Mask, ESD Strap, Cleanroom Gloves
  - Gloves over coverall cuffs and ESD straps
  - Hoods on right side out [seams and label on the inside]
  - Hoods tucked underneath bunny suit
  - Booties well strapped and over bunny suit
  - Polyethylene or Nitrile gloves when handling solvents
- Access
  - Required GSFC Code 540 Cleanroom Certification Course
    - Available through Satern website: https://satern.nasa.gov
    - Escort required unless LRO and Code 549 cleanroom certified
  - Personnel limited during Class 10,000 operations
    - Facility man-loading is limited to prevent contamination
  - Activate Air Shower if available
  - Ensure the use of a shoe cleaner or tacky mat



Common Mistakes

- Wearing heavy makeup, perfume, after shave, or cologne
- Picking up gloves by the fingers instead of the wrist-end when suiting up
- Keeping face mask below the nose
- Touching face or hair with gloves
- Failure to re-clean tools which have fallen on the floor or have been contaminated by use
- Failure to re-glove (or remove outer glove) after using epoxies or touching lubed bolts
- Bringing tools into the cleanroom without cleaning them (usually carried in a pocket, such as a pen)
- Walking or standing upstream of flight hardware
- Not using scissors to cut thru bags [scissors provided]
- Bringing regular paper into cleanrooms
- Using soiled garments [change is in order, after 3 uses or when garments become soiled]

Common Mistakes



Prevention

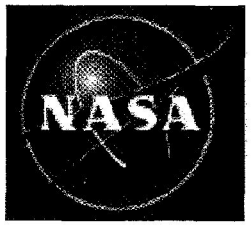
- Keep cleanroom wipes, polyethylene gloves, and alcohol in a squeeze bottle handy for recleaning tools and work surfaces
- Be aware of contamination sources and activities; inform contamination control
- Change your gloves when they become soiled and as often as necessary
- If you have to wipe or scratch your face while wearing gloves, use a dry cleanroom wipe, not your sleeve or gloved hands
- Follow cleanroom rules – use gentle reminders if needed
- Place bagging material or a pad on the floor before kneeling or working on the floor
- Use only approved materials for flight hardware, including lubricants and fasteners
- Use double gloves if working with lubes and epoxies; so that when the work is completed, the outer gloves can be removed
- Use scissors to cut plastic bags, don't tear bags
- Vacuum while drilling, abrading, and sanding
- **No** pencils, erasers, pens with rubber grips, retractable pens, wood, foam, silicone adhesives, easily flaked materials, sharpies, and of course **No** food or drinks

Prevention (Continued)

- **Silicone Adhesives** are prohibited in building 7/10/29/15 complex unless otherwise approved by Contamination Control/Code 546, Code 549, and the Materials Processing Review Board.
- Wet applications of epoxies or adhesives of any type require handling procedures to avoid contact transfer cross-contamination and ambient offgassing concerns to other projects.
- Ensure you contact Contamination Control for assistance with contamination mitigation techniques and approval
- **A Few Helpful Hints:**
  - Wear double/triple gloves; remove one, continue work with other
  - Wipe excess adhesives off with wipes, not garments or other tools
  - Have a trash can nearby
  - Use disposable garments

Prevention (Continued)

- Working in coveralls is fairly warm; dress appropriately
- Report problems or questionable materials / processes to contamination control and/or quality assurance
- Book proper sized Bakeout Chambers well ahead of time
  - Code 549 Thermal Vac: Mellina Espirtu [x 6-3906]
- Book I&T Facilities well ahead of time
  - Code 549 Facilities: Kim Cousler [x 6-4901]
- LRO Contamination Contact List:
  - Chris Lorentson [x 6-4904]
  - Rachel Rivera [x 6-0542]
  - Patsy Dickens [x 6-9735]
  - Glenn Rosecrans [x 6-2790]
  - Marcello Rodriguez: Purge questions [x 6-0564]
- ManTech CC Contact : [x 6-0952] or Leon Bailey [x 6-9667]



Summary

- The Lunar Reconnaissance Orbiter is poised to conduct exciting lunar research to characterize future robotic and human lunar landing
- The instruments (LOLA, LAMP, LROC, DIVINER, CRaTER), Star Trackers, and Critical Surfaces have stringent contamination controls in order to meet mission objectives
- All Flight Hardware and GSE coming into contact with Flight Hardware have contamination requirements
- Class 10,000 Cleanrooms or clean tents will be used
  - Personnel must wear full cleanroom suits with gloves and masks
- Clean all tools, wrist straps, and GSE prior to entering the cleanroom
- Your efforts and compliance with LRO's contamination control program is greatly appreciated and helps ensure a successful mission

National Aeronautics and Space Administration

LRO - Lunar Reconnaissance Orbiter

PLEASE ANSWER THE FOLLOWING QUESTIONS

Please select the best answer to the following:

Sample questionnaire

1 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In vel nunc?

○ 25 ○ 35 ○ 1000 ○ 10.25

2 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In vel nunc?

○ daily ○ weekly ○ monthly ○ every 2 years

3 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In vel nunc?

○ 25 ○ 35 ○ 1000 ○ 10.25

4 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. In vel nunc?

○ daily ○ weekly ○ monthly ○ every 2 years

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