Practical Cleanroom Operations Constraints

Amani Ginyard
David Hughes

2007 Contamination & Coatings Engineering Workshop
Background

- Hubble Space Telescope Servicing
  - Contamination sensitive instruments
    - Wide Field Camera 3 (WFC3)
    - Cosmic Origins Spectrograph (COS)
    - Fine Guidance Sensor (FGS)
  - Large space support equipment (carriers)
    - Flight Support System (FSS)
    - Orbital Replacement Unit Carrier (ORUC)
    - Super Lightweight Interchangeable Carrier (SLIC)
    - Multi-Use Lightweight Equipment (MULE)
  - Miscellaneous refurbishment items
    - Batteries, Rate Sensor Units (RSU), New Outer Blanket Layer (NOBL)
    - Space Telescope Imaging Spectrograph (STIS) repair
    - Advanced Camera for Surveys (ACS) repair
GSFC Cleanroom Facility

- Spacecraft Systems Development and Integration Facility (SSDIF)
  - 90 feet wide by 120 feet long
  - Horizontal unidirectional flow cleanroom
  - Additional Features:
    - Access cleanroom via 25’x40’ overhead rollup door
    - Two 35 ton cranes with heights of 69’ and 80’
    - Precision Cleaning Facility
    - Hardware Storage Area

2007 Contamination & Coatings Engineering Workshop
WFC3 Integration

- Instrument integration
  - Long periods of work on optical bench
  - Positioned near front of room in SSDIF (close to filter wall)
  - Restricted access to WFC3 area
  - Limited space for hardware movement
  - Extra training for contamination sensitivity
WFC3 During Integration
Operational Constraints

- Why constrain cleanroom activities?
  - Particle counts increase
  - Potential for reactive molecular contaminants
    - During bonding activities
  - Turbulent flow around hardware
    - Transport particles "upstream"
  - Potential for anomalies
    - Crane
      - Light fixture impact
    - Power failure
      - Lift Operations
      - Rollup door
    - High Humidity
    - Water Leak
    - Fire
Constraint Table

- Created for consistency within Contamination Control Team
- Presented during “Refresher” Training for entire project
  - Overview only
  - Constraints added to work orders by CC team
- I&T manager requested a written copy
<table>
<thead>
<tr>
<th>Restricted Activity</th>
<th>Open (Optics or Optical Bench Exposed)</th>
<th>Closed (Draped) (Enclosure Exposed, Aperture/Optics Covered)</th>
<th>Bagged (Instrument may be draped and taped)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonding / Staking / Lubricating</td>
<td>Prohibited within 10'</td>
<td>&lt; 6 g within 10'</td>
<td>&lt; 30 g within 10'</td>
</tr>
<tr>
<td></td>
<td>&lt; 6 g within 30'</td>
<td></td>
<td>Quantity within reason</td>
</tr>
<tr>
<td>Sanding / Abrading / Drilling</td>
<td>Prohibited upstream</td>
<td>Prohibited upstream</td>
<td>No Constraints</td>
</tr>
<tr>
<td>(Vacuum pickup of debris during generation)</td>
<td>&gt; 6 feet away for man-sized objects</td>
<td>&gt; 6 feet away for man-sized objects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;20 feet away for larger objects</td>
<td>&gt;20 feet away for larger objects</td>
<td></td>
</tr>
<tr>
<td>Crane Operations</td>
<td>Prohibited</td>
<td>Prohibited upstream</td>
<td>No Constraints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;20 feet away for man-sized objects</td>
<td></td>
</tr>
<tr>
<td>SSDIF Maintenance</td>
<td>Prohibited</td>
<td>Prohibited upstream</td>
<td>No Constraint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;20 feet away for man-sized objects</td>
<td></td>
</tr>
<tr>
<td>Large Structure Cleaning</td>
<td>Prohibited</td>
<td>Prohibited upstream</td>
<td>No Constraint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;20 feet away for man-sized objects</td>
<td></td>
</tr>
<tr>
<td>Large Structure Unbagging</td>
<td>Prohibited Upstream</td>
<td>Prohibited upstream</td>
<td>No Constraint</td>
</tr>
<tr>
<td></td>
<td>&gt; 30 feet away for man-sized objects</td>
<td>&gt;20 feet away for man-sized objects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>larger objects prohibited</td>
<td>&gt;40 feet away for larger objects</td>
<td></td>
</tr>
<tr>
<td>Hardware Movement</td>
<td>Prohibited Upstream</td>
<td>Prohibited Upstream</td>
<td>No Constraint</td>
</tr>
<tr>
<td></td>
<td>&gt; 30 feet away for man-sized objects</td>
<td>&gt; 6 feet away for man-sized objects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>larger objects prohibited</td>
<td>&gt;20 feet away for larger objects</td>
<td></td>
</tr>
<tr>
<td>Personnel Activity</td>
<td>&lt; 5 within 10'</td>
<td>&lt; 10 within 10'</td>
<td>No Constraint</td>
</tr>
<tr>
<td></td>
<td>(SSDIF Max: 10)</td>
<td>(SSDIF Max: 40)</td>
<td>(SSDIF Max: 40)</td>
</tr>
<tr>
<td>Air Bearing Use</td>
<td>Prohibited</td>
<td>Prohibited upstream</td>
<td>No Constraint</td>
</tr>
<tr>
<td>(Allow 30 minutes of settle time after use)</td>
<td></td>
<td>&gt;30 feet downstream</td>
<td></td>
</tr>
<tr>
<td>Door Opening</td>
<td>Prohibited</td>
<td>Prohibited</td>
<td>No Constraint</td>
</tr>
<tr>
<td>(Allow 30 minutes of settle time after door closing)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Revisions

- Changed column definitions
  - Confusion between open, closed, draped and bagged
  - Defined draped
    - Cover entire instrument with sufficient material to hang along sides
  - Defined bagged
    - Llumalloy taped and fitted tightly enclosing entire instrument

- Personnel Limits
  - Contamination sensitive I&T operations for hardware besides WFC3

- Waive Constraints: Case by Case
  - Unplanned operations
  - Slight changes in Instrument Configuration
    - Mostly bagged with small openings
  - Special Visits: Astronaut Training, News Press, Tours
More Confusion

- COS instrument
  - Moved to back of room for optical testing
  - Fixed zones did not account for move

- HFMS
  - Directly on boundary of zones
  - Approved use of man-lift work
<table>
<thead>
<tr>
<th>Condition:</th>
<th>WFC3 Unbagged (Loose Drape)</th>
<th>WFC3 Bagged (Drape and Tape)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bonding / Staking / Lubricating</td>
<td>&lt;6g</td>
<td>&lt;30g</td>
</tr>
<tr>
<td>Sanding/Abrading/Drilling</td>
<td>Downstream</td>
<td>&lt;6' above floor</td>
</tr>
<tr>
<td>Crane Operations</td>
<td>WFC3 only</td>
<td>Prohibit</td>
</tr>
<tr>
<td>Air Bearing Use (Allow 30 minutes of settle time after use)</td>
<td>Prohibit</td>
<td>Prohibit</td>
</tr>
<tr>
<td>Insert/Remove Bolts</td>
<td>&lt;6' above floor</td>
<td>&lt;6' above floor</td>
</tr>
<tr>
<td>Door Opening (Allow 30 minutes of settle after door closing)</td>
<td>&lt;6' high</td>
<td>&lt;6' high</td>
</tr>
</tbody>
</table>

2007 Contamination & Coatings Engineering Workshop
SSDIF Restrictions

- SSDIF restrictions of activities are driven by condition of Science Instruments (SI)
  - Unbagged, Draped, Bagged
- 3 Major Categories of SSDIF Activities
  - Relocation of Hardware
    - Lifts, Air Bearings, Door Openings
  - Hardware Activity
    - Painting, sanding, drilling, bonding, staking, soldering
  - Contamination Control Operations
    - Maintenance, Cleaning, Hardware Bagging/Unbagging
- Types of Restrictions
  - Personnel Limits: <15 SI Unbagged, 40 max
  - Time limits before opening SI: 30 min.
  - Distance away from SI: <6 ft. from ground, >10 ft. away from SI
  - Quantity of material: <30g of staking material
Decision Tree

- Switched to decision tree
  - 3 Main Categories for Constraints
    - Hardware Relocation
    - Hardware Work
    - Contamination Operation
  - User Friendly
    - Answers most often asked questions
  - Provides additional new response: Call CCE

- Designed tree to support independent planning assessment by I&T manager
  - Many activities are easy to identify as ok or not ok
  - The remainder end in a “Call CCE” decision
  - Retained final authority at daily I&T meeting
Decision Tree – Hardware Relocation

- **Start**
  - Is an SI open?
    - Yes
      - Are there < 10 people in the SSDIF?
        - No
          - Are there < 40 people in the SSDIF?
            - No
              - Postpone entry until < 40 people remain in SSDIF or SI becomes bagged or draped
            - Yes
              - Postpone entry until < 10 people remain in SSDIF or SI becomes bagged or draped
        - Yes
          - Will hardware be relocated?
            - No
              - Go to hardware work flow chart
            - Yes
              - Will a crane be operated?
                - No
                  - Will a manlift be operated?
                    - No
                      - Will air bearings be operated?
                        - No
                          - Will hardware be moved by hand?
                        - Yes
                          - Is an SI open?
                            - Yes
                              - Is an SI open?
                                - Yes
                                  - Is an SI open?
                                    - Yes
                                      - Will hardware be moved by hand?
                                    - No
                                      - Is an SI open?
                                        - No
                                          - Will air bearings be operated?
                                            - Yes
                                              - Is an SI open?
                                                - Yes
                                                  - Is an SI open?
Decision Tree - Hardware Work

Will the work require bonding or staking?  
No

Will the work require lubrication?  
Yes

Is an SI open?  
Yes

Will the work occur > 10 ft from an SI?  
Yes

OK with < 30 g  

On SI only or < 6 g  

No

Will the work require soldering?  
Yes

Is an SI draped?  
Yes

OK  

No

Is an SI bagged?  
Yes

OK  

No

Will the soldering occur < 10 ft away from an SI?  
Yes

For SI only  

No

Is the harness < 6 ft in length?  
Yes

Will the work require harness routing?  
Yes

Is an SI open?  
Yes

Call CCE  

No

Will the work occur > 10 ft from an SI?  
Yes

OK
Decision Tree
Contamination Control Operations

Will contamination operations be performed?
- Yes
  - Will SSDIF maintenance be performed?
    - Yes
      - Call CCE
    - No
      - Will hardware be unbagged?
        - Yes
          - Is the object > 6 ft tall?
            - Yes
              - OK
            - No
              - Is the object > 20 ft from an SI?
                - Yes
                  - OK
                - No
                  - SI only
        - No
          - Will the cleaning be < 10 ft from an SI?
            - Yes
              - OK
            - No
              - Call CCE
      - No
        - Will hardware be bagged?
          - Yes
            - Is the object > 6 ft tall?
              - Yes
                - OK
              - No
                - Is the object > 20 ft from an SI?
                  - Yes
                    - OK
                  - No
                    - SI only
          - No
            - Will cleaning be performed?
              - Yes
                - OK
              - No
                - Call CCE

2007 Contamination & Coatings Engineering Workshop
Conclusion

- CCE must attend all I&T meetings
  - Need to have CC representative to address on the spot decisions
  - Schedule changes effects coordination of activities
  - CC Technicians must be informed to be prepared ahead of time
- CCE must be clear and consistent in communication to Project Team
- CC Team has to be aware of current and near future activities for all hardware
  - Coordinate with Project and adjust quickly to schedule changes
- Project is responsible for providing detail information of I&T activities
  - Personnel required
  - Type of activity
  - Specific location
  - Time duration
  - Materials, test equipment, tools