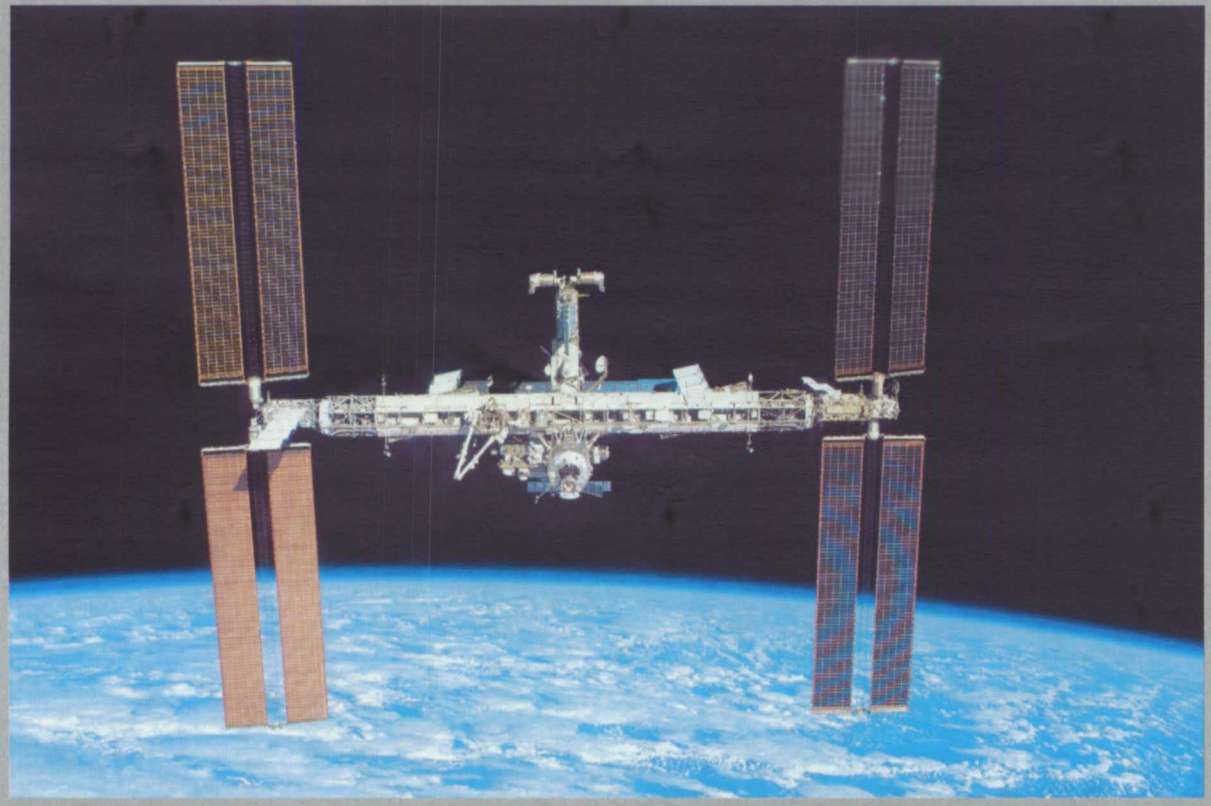
National Aeronautics and Space Administration

International Space Station EVA Wipe
An extraordinary sample from a far-out place



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Introduction

- **Contamination control is critical in space flight, where failure is not an option.**
  - Decrease performance of sensors and detectors on payloads.
    - Satellites star tracker sensors … billion dollar spacecraft depend on them for their performance on orbit.
  - Particles act as projectiles-micrometeorites which could result in damage to flight hardware.
    - "Laws of Motion: Once in motion…"
      - Shuttle slows down upon approaching the ISS, thus launching foreign object debris (FOD).
      - Paint chips have been reported as projectiles equivalent to .22 caliber bullets.
  - Damage to seals and may cause air leaks.
  - Health hazard to crew.
    - New modules.
      - Eye protection and face mask are required for entry until several air changes.

Visually Clean Requirements

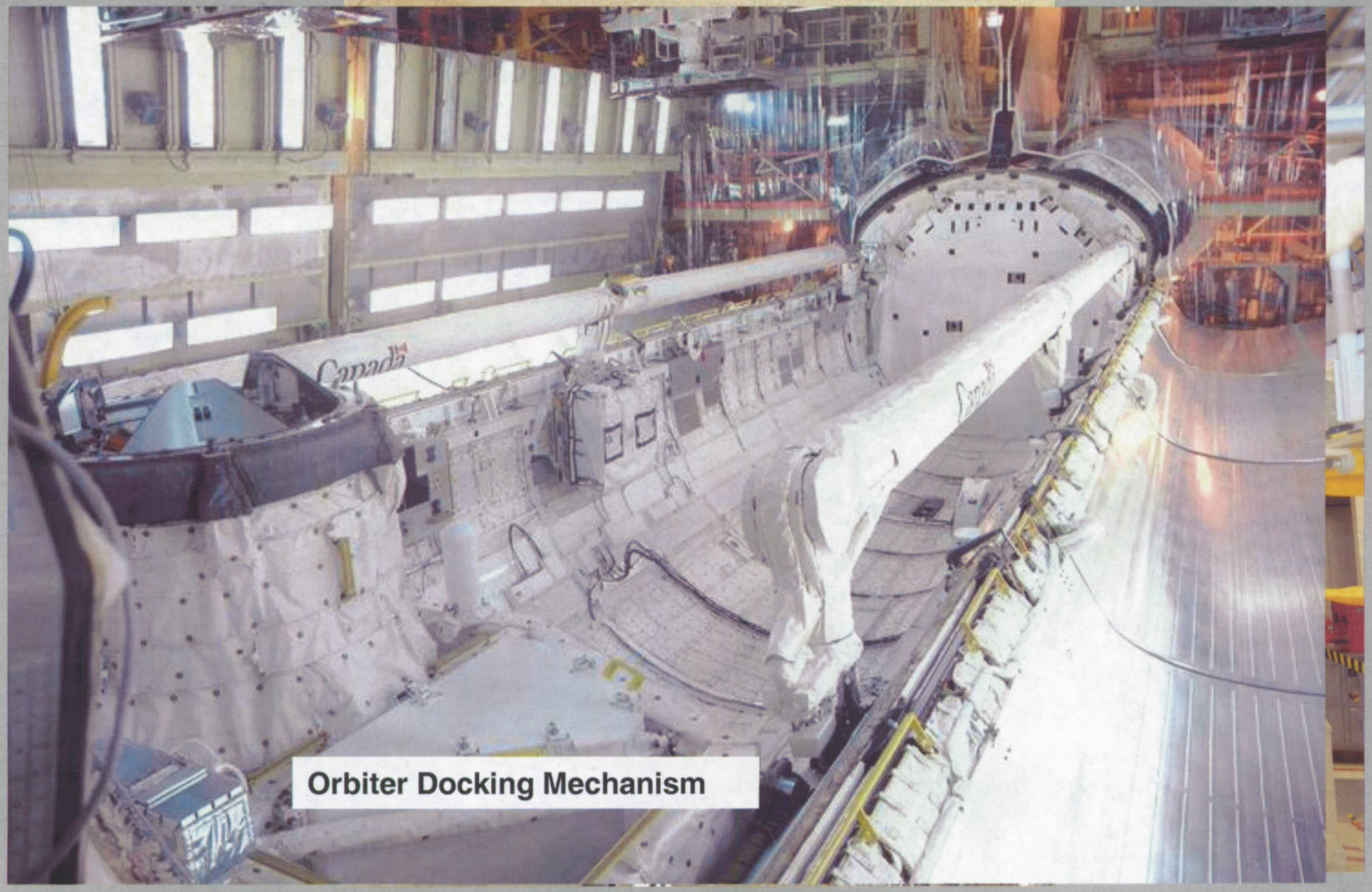
- To protect International Space Station (ISS) flight hardware the aerospace industry depends upon visually clean requirements.
  - Visually clean is somewhat arbitrary and subjective.
    - Aerospace payload and flight hardware communities have totally different standards.
    - Flight hardware inspection standards specify inspection distance under specific lighting conditions SN-C-0005, Visibly Clean.

– Standard	5-10 feet with light level of >=50 FT-candles
– Sensitive	2-4 feet with light level of >= 50 FT-candles
– Highly Sensitive	6-18 inches with light level > 100 Ft-candles and uv black light inspection. (CBM seal)

- A policy of "clean as you go" as well as an active FOD program promotes cleanliness.

Orbiter Processing Facility

We fly out of a barn.



Orbiter Docking Mechanism

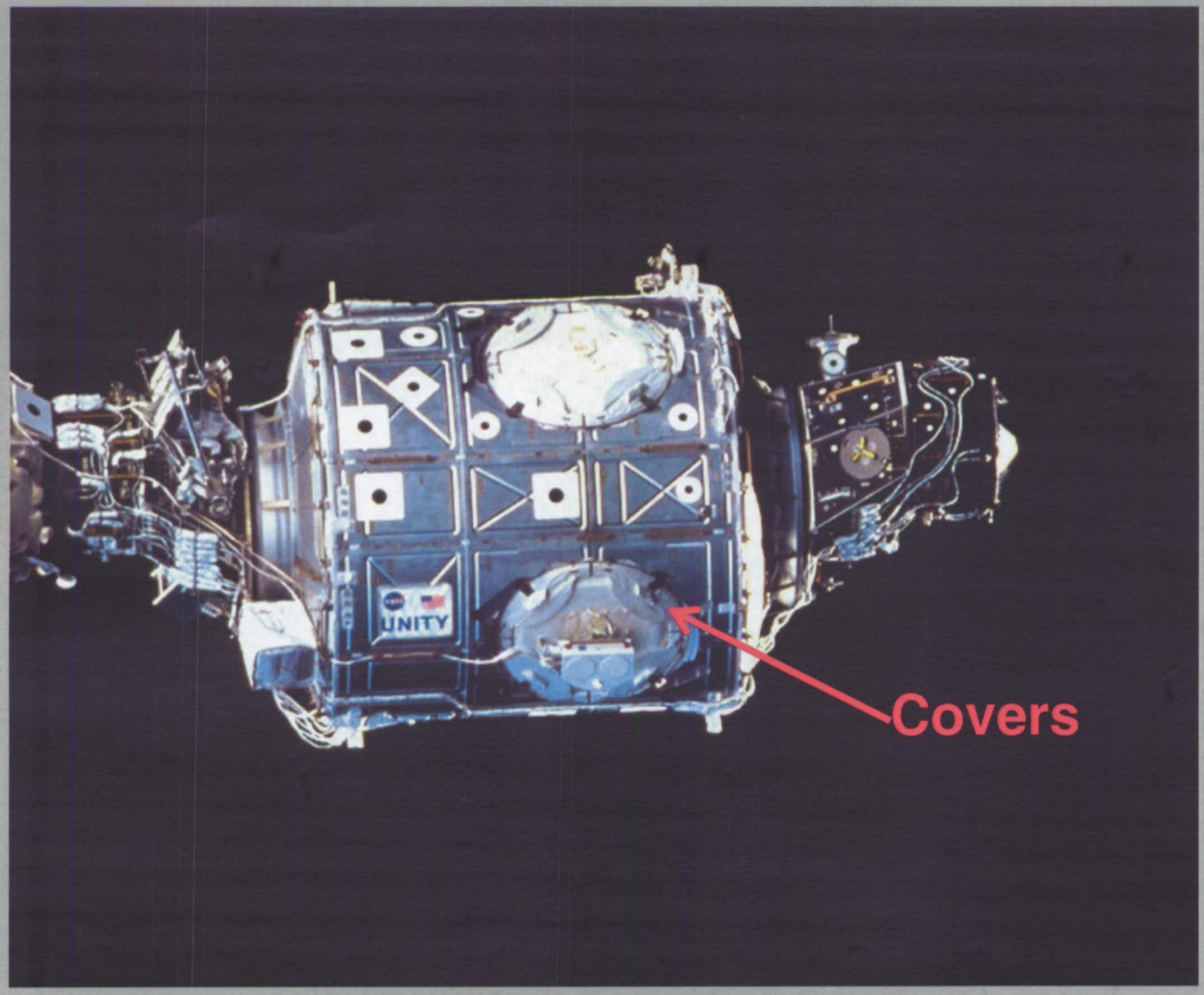
ISS EVA Decision

- Inspection of the Unity Node Earth-facing Active Common Berthing Mechanism (CBM) confirmed contamination was present.
- An extra-vehicular activity (EVA) was scheduled for Expedition 15 EVA 9 on 23 July 2007.
  - EVA #9 objectives were to include:
    - Removal and jettison of Early Ammonia Servicing reservoir.
    - Cleaning of the Node 1 nadir port with a EVA wipe for relocation of Pressurized Mating Adapter 3.
    - Several of get-ahead tasks in preparation for future EVA's.
- After traveling 38,098,924 miles (1,648 orbits) the EVA wipe was returned to earth on 7 Nov 2007.
- Objective was to clean the sealing surface and to recover the particles to determine the possible source of the contamination.
    - Transfer contamination from flight hardware delivered to the ISS.
    - Shuttle contamination in the cargo bay landing on the surface of the seal .
    - On-orbit contamination from venting of seal on de-mates.
    - Space junk.

Common Berthing Mechanism

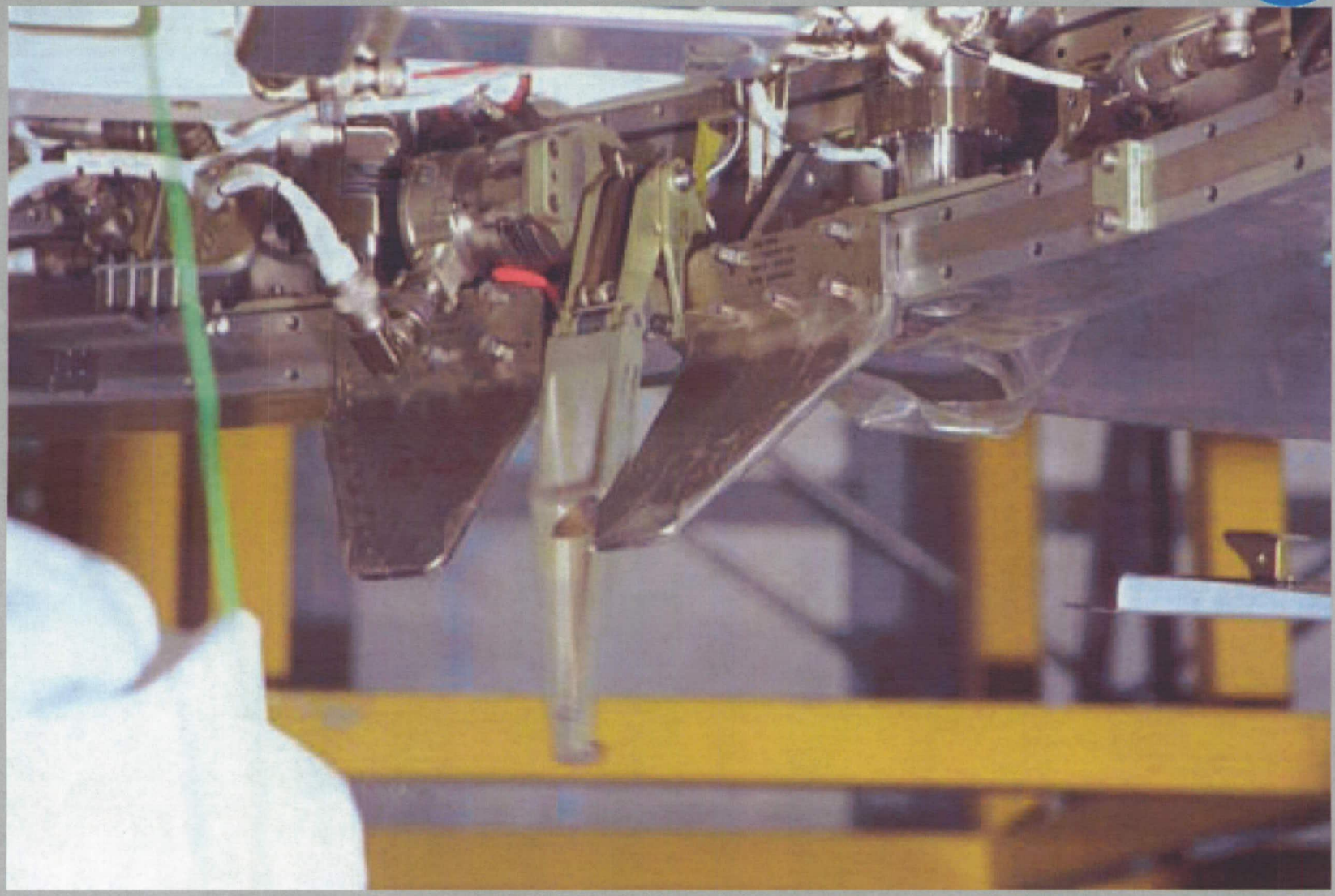
- The CBM is the common interface of all United States payloads with the ISS.
  - Space Shuttle
  - Multi-Purpose Logistic Modules (MPLM)-Italian Space Agency
    - Leonardo, Raffaello and Donatello
      - MPLMs Serve as the ISS's "moving vans," carrying equipment, experiments and supplies to and from the ISS aboard the Space Shuttle.
- Leonardo and Raffaello MPLM have each been berthed to Unity Node 1 on multiple missions. Upon returning, the MPLM contained contamination analyzed on previous reports from STS-114 and STS-120 missions.

Unity Node 1 CBM with Pressurized Mating Adapters (PMA)



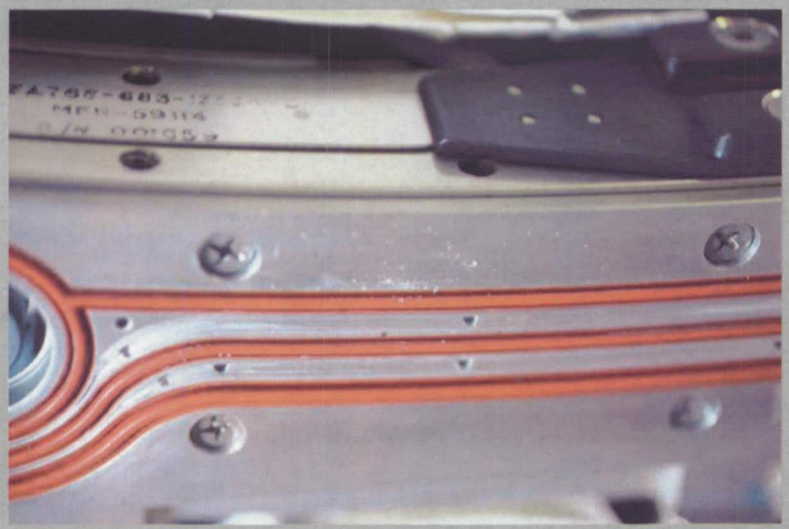
CMB Active and Passive seals

Capture latches, alignment guides, powered bolts

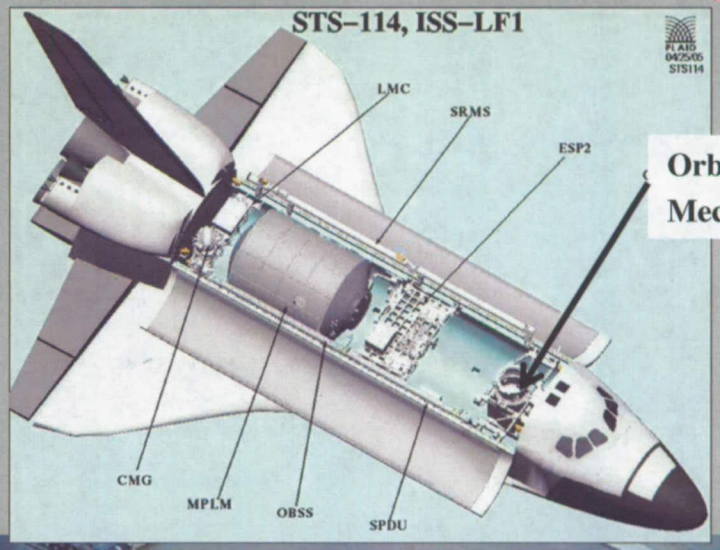


MPLM Seals from STS-114

- Debris on the sealing surface raises concern of seal failure or damage. The seals are redundant for this reason. Estimated point of contact of the sealing surface, 1.5 mm.
- The fluorinated lubricant Braycote® 601 makes for an efficient collector of debris.
- Mylar covers were developed for the MPLM seal during processing and removed before flight. A permanent flight cover was deemed not feasible to remove while on orbit.
- Due to the vertical orientation and location of the MPLM seal in the cargo bay, debris can be deposited at launch.

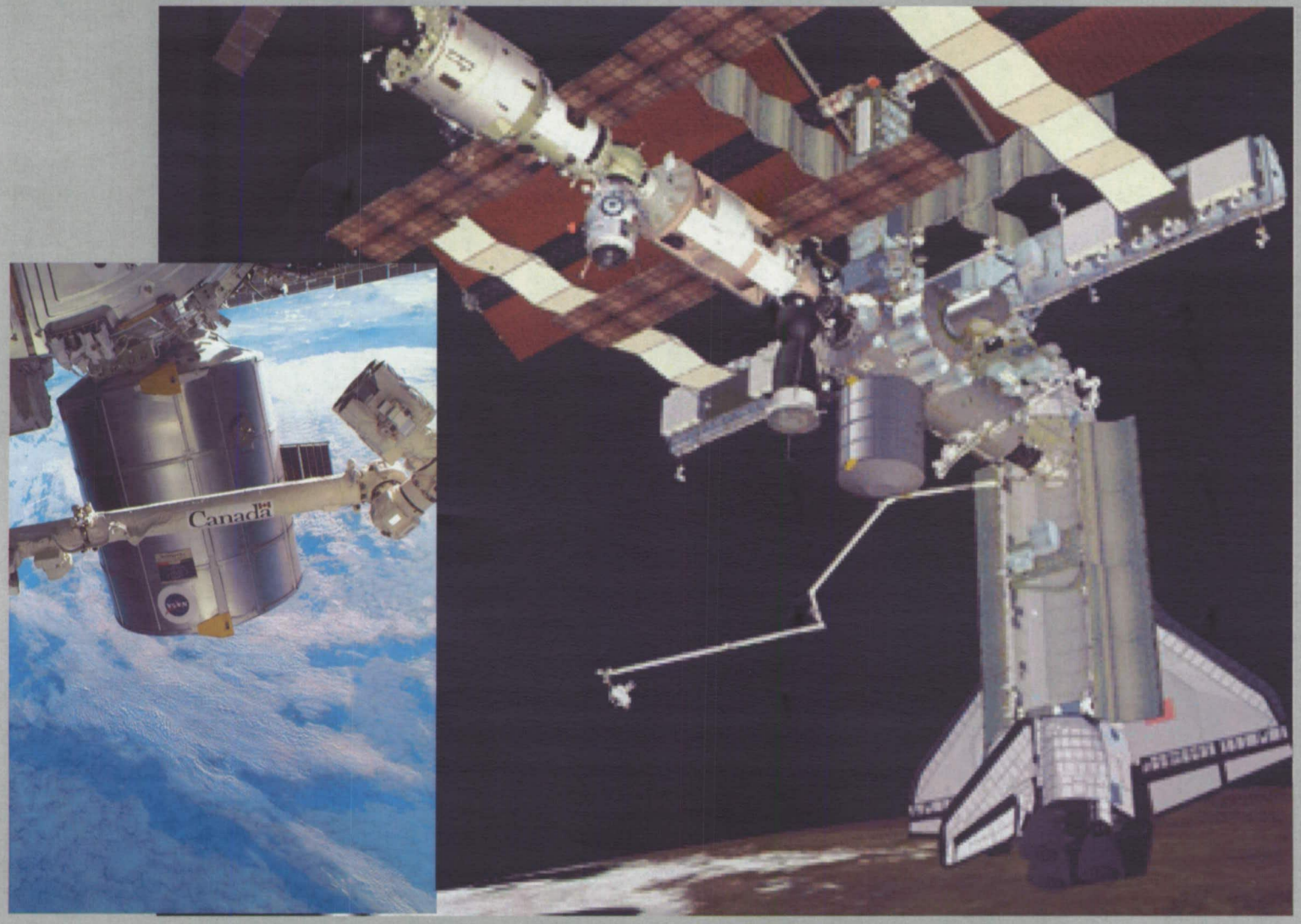


Leonardo MPLM delivery to ISS



Orbiter Docking Mechanism

MPLM Delivery to the ISS nadir CBM

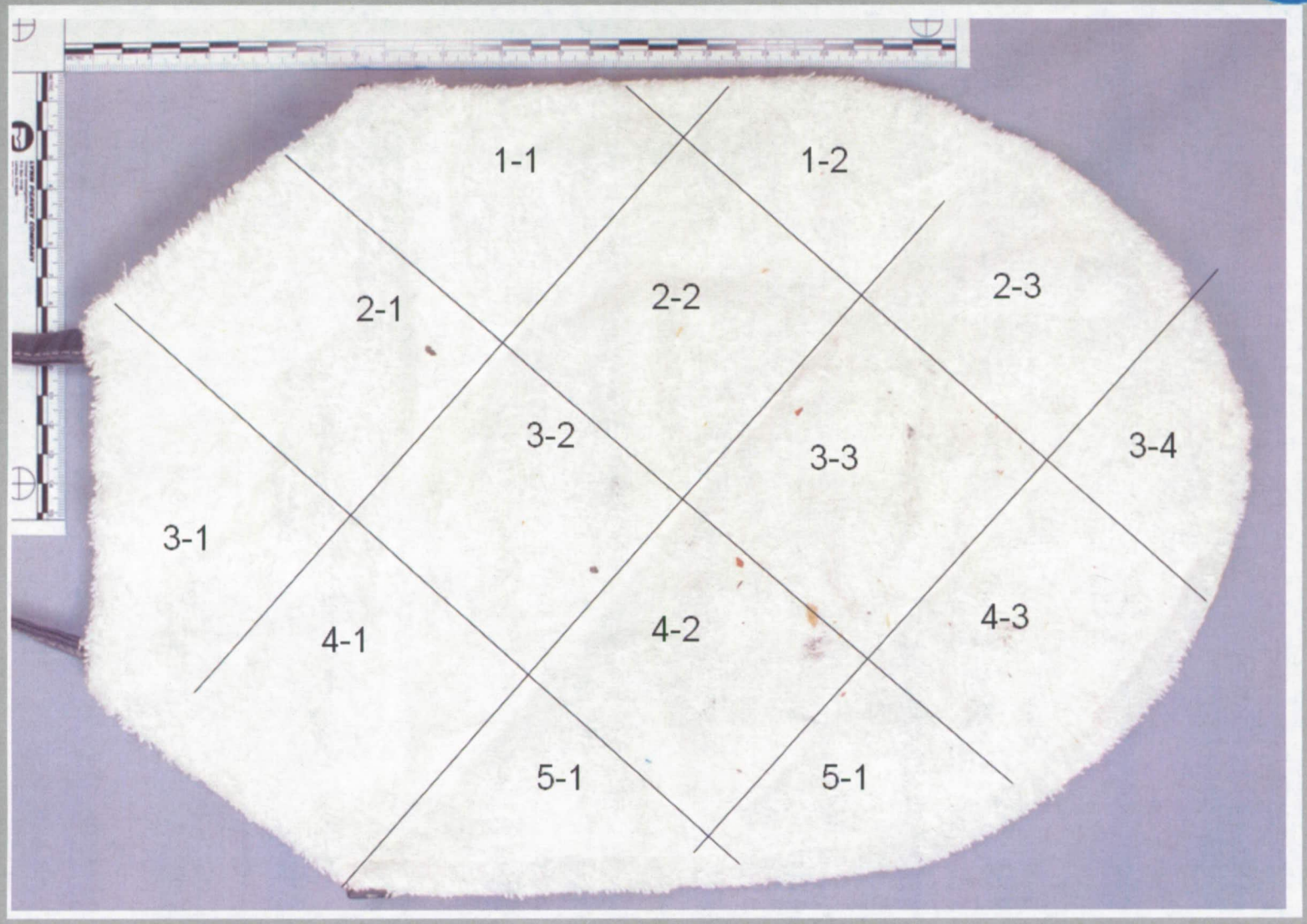


Analysis of the EVA Wipe

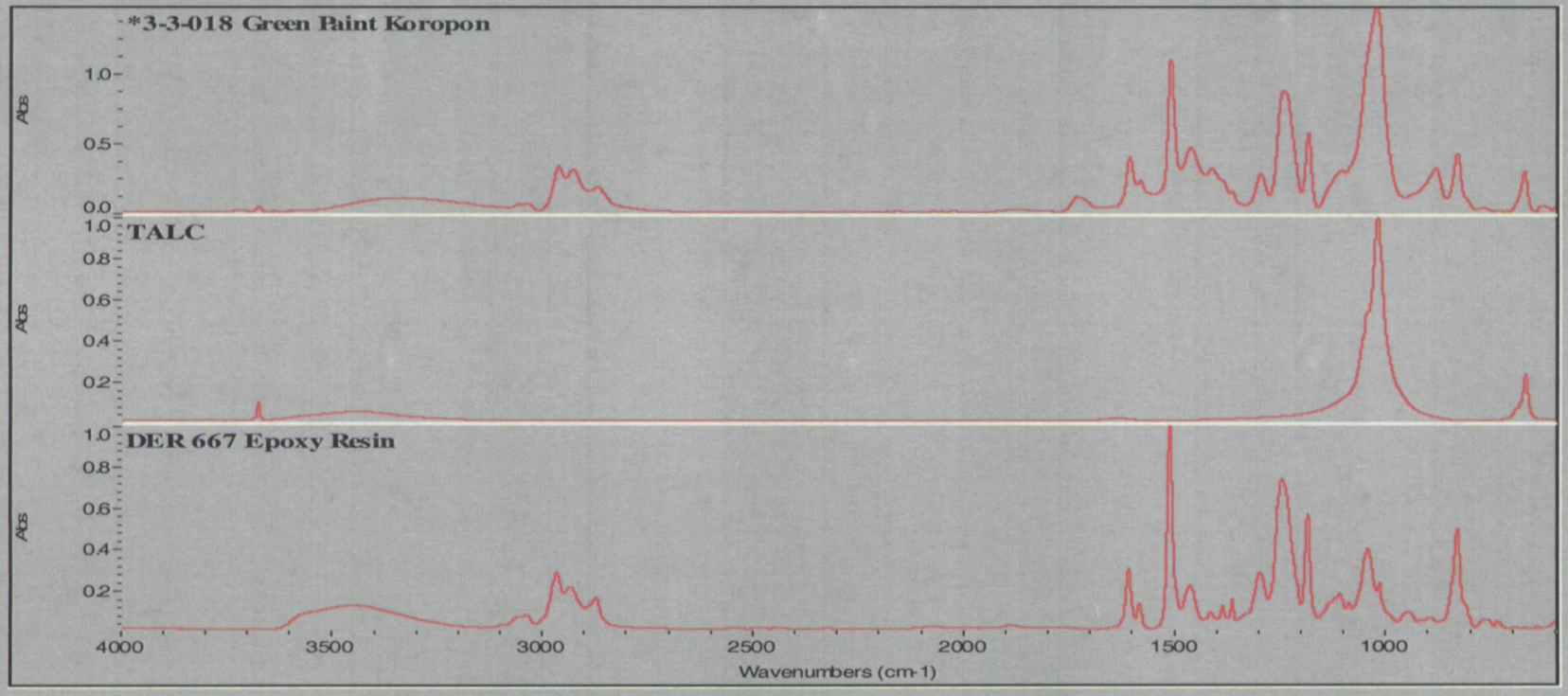
Stereo microscopic examination at 15 and/or 45 X

- Photo documentation of particles as received on wipe.
  - Physical description, color, approximate size and location for numbering of particles only. (The relative orientation of the particles on the wipe was not considered significant.)
- Removal of particle for mounting on carbon tape.
  - Further description, visual measurements.
- Scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) analysis.
  - Critical dimensions
  - Elemental analysis
- Fourier transform infrared (FT-IR) analysis of organics and fibers.

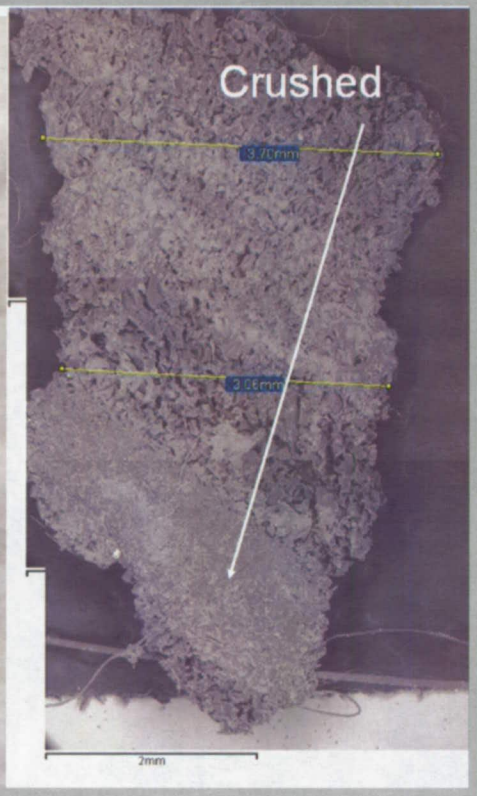
EVA wipe, multi-ply (part number SED33116397-703)

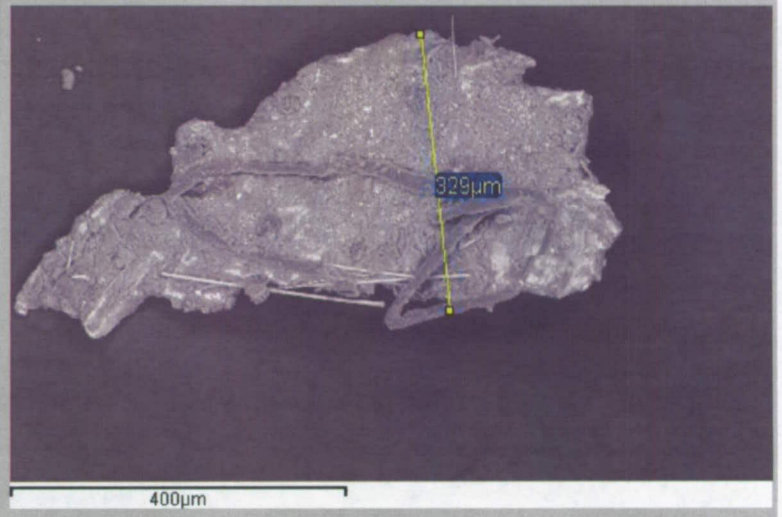


FT-IR Analysis Example



Particle Morphology





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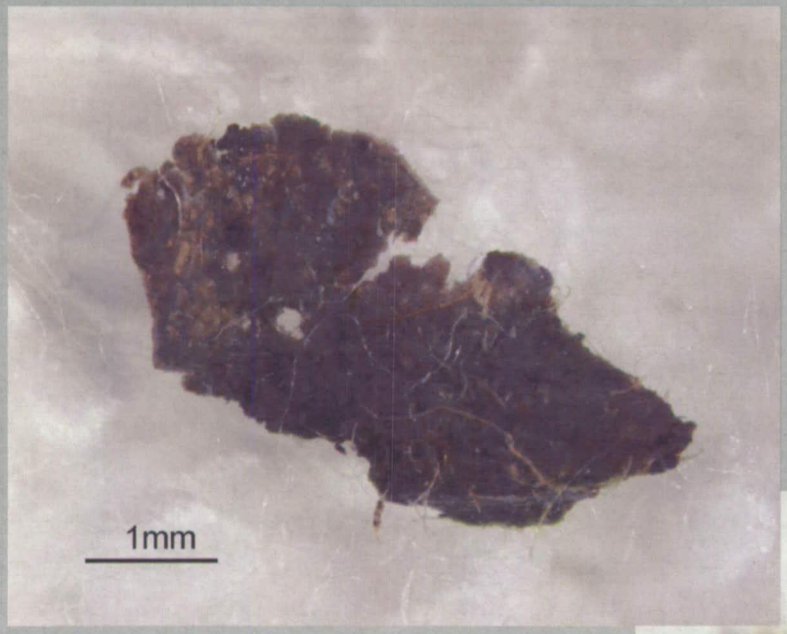
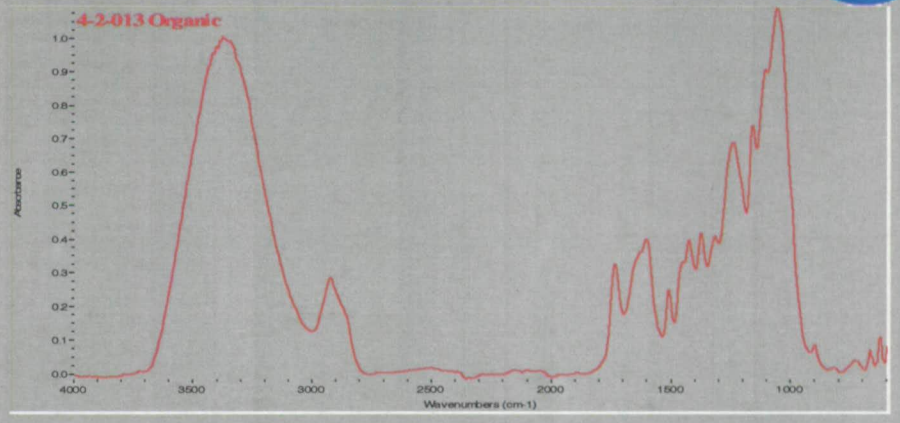
Visual vs SEM four quadrant backscatter detector (QBSD) images

Analysis Summary

Category	Total Particles
Biological	6
Fibers, individual colored	44
Grease (fluorinated grease) with solids	
-collection everything dominated with fibers	27
Metals	36
Paint	22
Plastic	34
Misc.	3
Total Particles	**172**

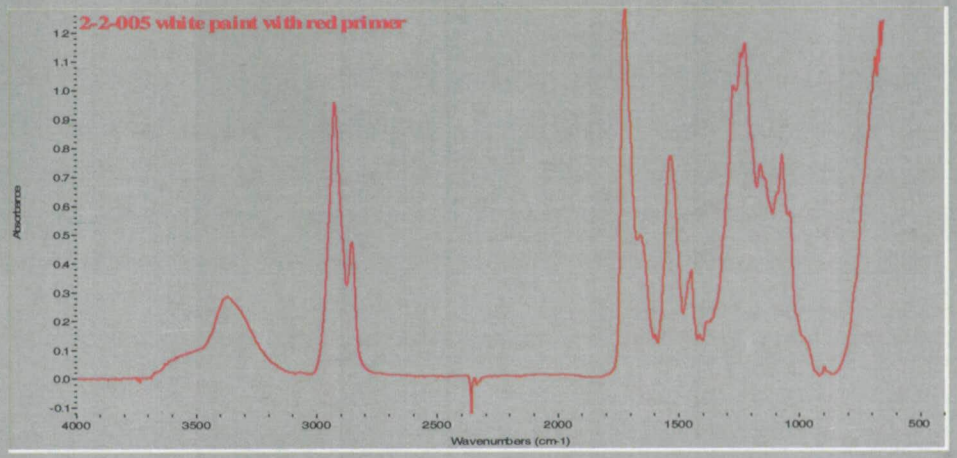
Biologicals

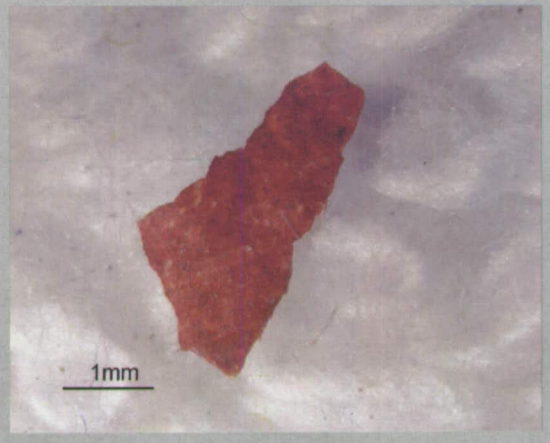


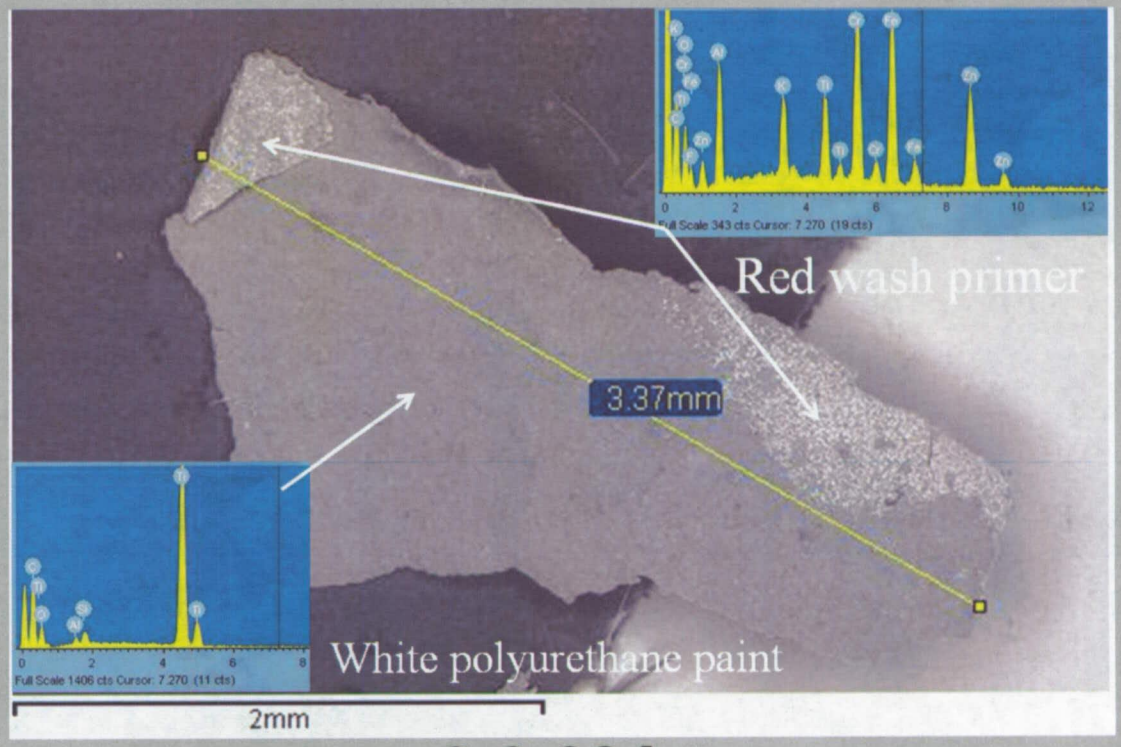


Paints

- Observations
  - Color -White coating
    -Red primer
  - Layers-two
  - Thickness -30 μm coating
    - 8 μm primer
  - Resin -Polyurethane
  - Inorganic fillers
    Coating Ti, trace Al and Si
    Primer Fe, Zn, Cr, trace Sr







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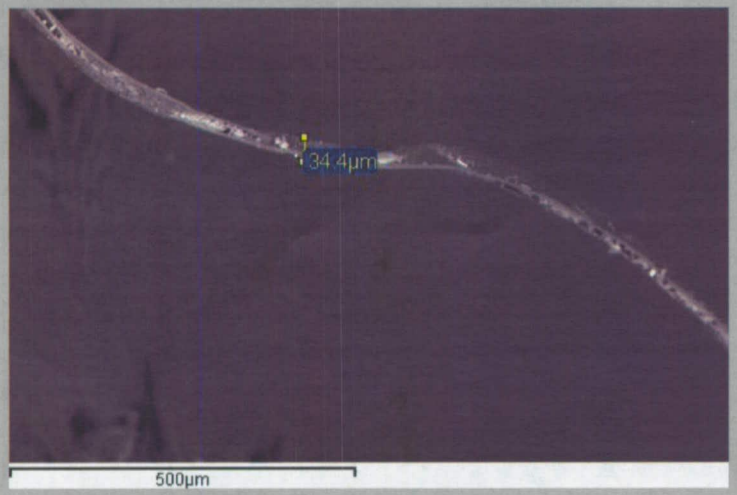
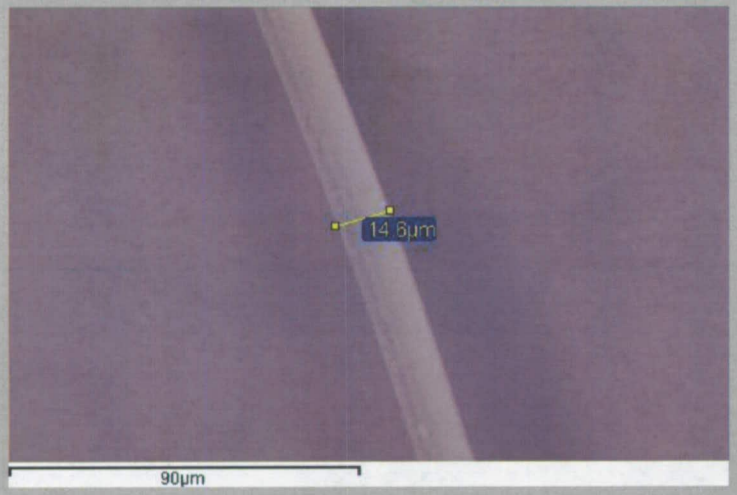
Fibers

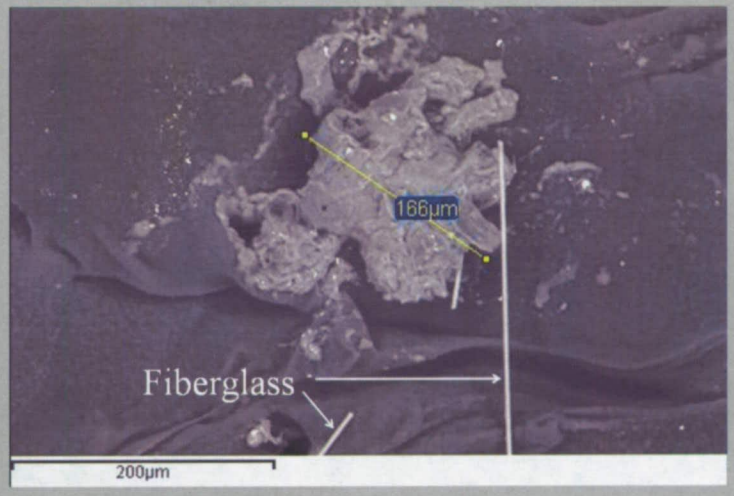


(2-1-001) Cotton fiber

(2-1-004) Hair fiber

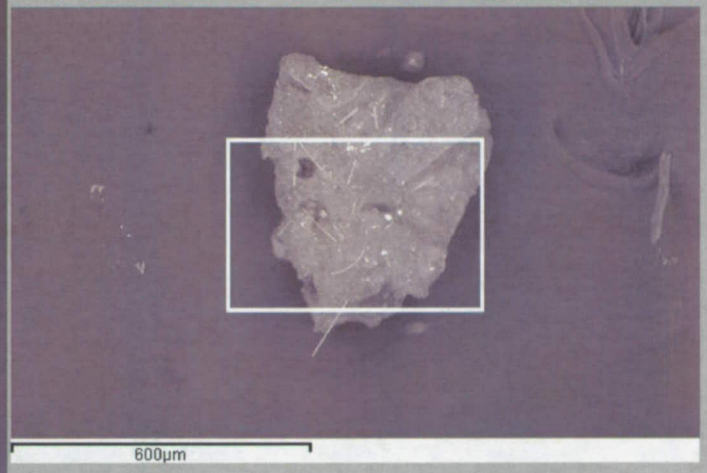


(2-2-004) Synthetic aramid fiber

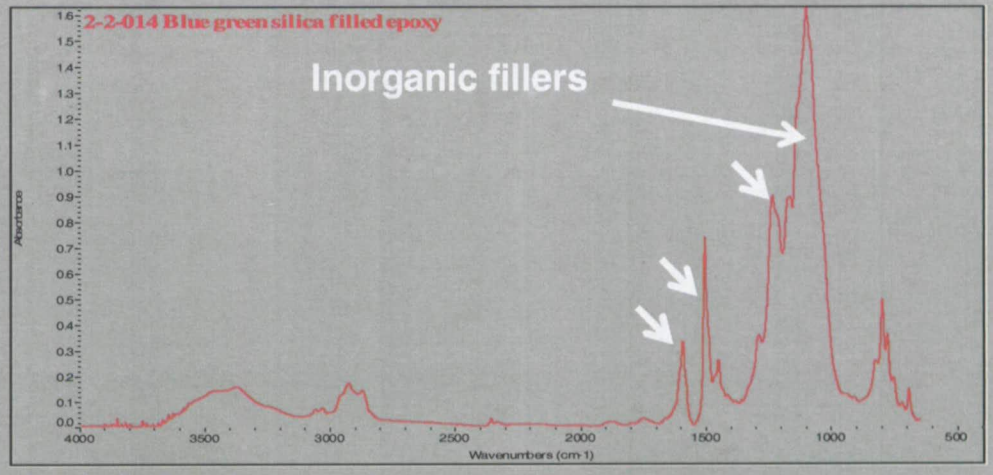


(2-2-008) Fiberglass in grease

Plastic



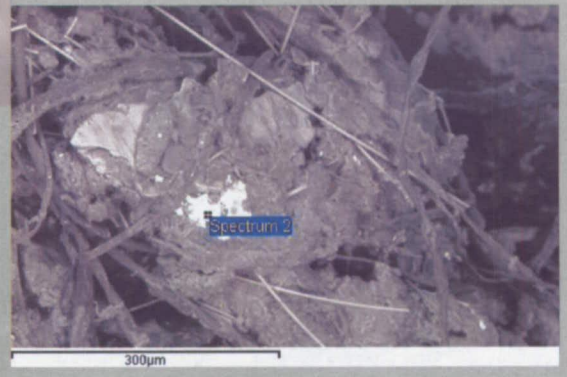
Blue-green silica filled epoxy found on previous samples from MPLM.



Grease

(4-3-004) Grease with paint, metals, fibers, silicone RTV, biological, etc.

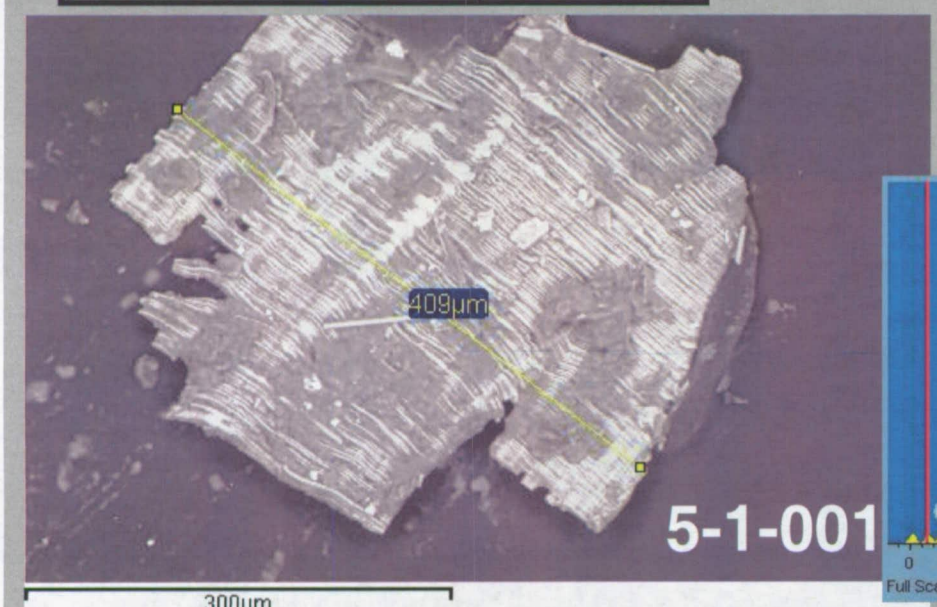
(2-2-011) Grease with fibers and metals.

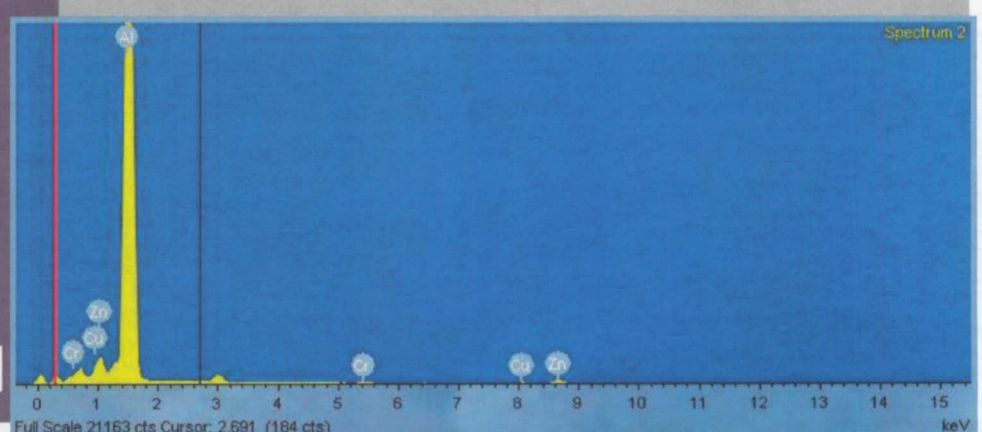


Metal Alloy Identification

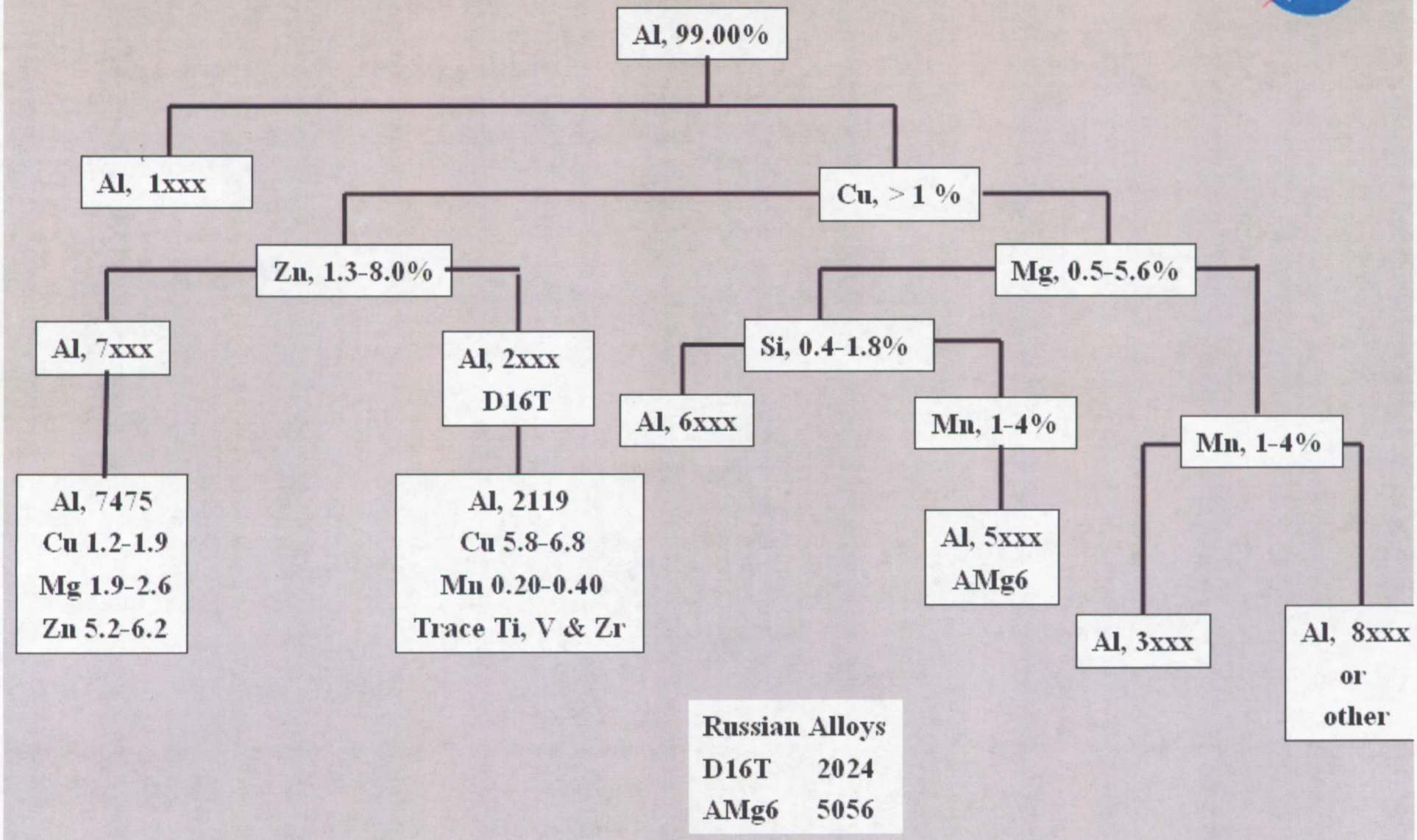
Element	Series
Aluminum , >99.00	1xxx
Copper	2xxx
Manganese	3xxx
Silicon	4xxx
Magnesium	5xxx
Magnesium and Silicon	6xxx
Zinc	7xxx
Other Elements	8xxx

- **MatWeb**
  - **www.matweb.com/search/CompositionSearch.aspx**
  - **http://www.matweb.com/search/CompositionSearch.aspx**
  - **Material databases**
    - **–Materials certified for use on flight hardware**
    - **– Search by alloy and part**





Al Alloy Series Identification by Specification Limits



A View from Above!

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