PREFERRED RELIABILITY PRACTICES

CONTAMINATION BUDGETING FOR SPACE OPTICAL SYSTEMS

Practice:

Use preplanned contamination budgeting for each manufacturing/assembly, testing, shipping, launch, and flight operation and meticulously test optical systems using witness samples throughout the process to track actual contamination against total and incremental allocations.

Benefit:

Budgeting of a specific amount of the established allowable contamination to the major elements and operations during fabrication, assembly, testing, transportation launch support, and launch and on orbit operations of space optical systems will preclude jeopardizing the scientific objectives of the mission. Budgeting of contamination to major elements will ensure that the cleanliness of the optics and instruments will remain within designated optical requirements for operations in space. Reliability of the scientific objectives are increased by limiting the contamination allowed to the optical systems during each operation, which ensures that contamination during orbital operations is within specification.

Programs That Certified Usage:

Apollo Telescope Mount (ATM), High Energy Astronomy Observatory (HEAO), Hubble Space Telescope (HST), Advanced X-Ray Astrophysics Facility (AXAF).

Center to Contact for More Information:

Marshall Space Flight Center (MSFC)

Implementation:

1. Introduction

Contamination budgeting allocations for optical systems should be developed by the chief scientist, systems engineer, and the contamination control engineer using information generated from requirements documents, interface control documents, science working groups, contamination control working groups, contamination control review panels, contamination effects analyses, contamination testing programs, and direct customer involvement. The experience gained from other programs to budget and control contamination is also an input to the determination of a contamination budget. Another factor that should be considered is the cost of controlling contamination versus the scientific

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payback. The effective control of contamination may require: (1) investments in clean room facilities, (2) training of personnel in clean room operations, (3) monitoring of clean room activities and air quality, (4) acceptance of inefficiencies in working conditions caused by special clothing, restricted space and contamination avoidance provisions, and 5) potential performance tradeoff (i.e., use of cleanable or conductive coatings, modified thermal controls, and use of windows).

2. Budgeting for Contamination

The two principal types of contamination sources for optical systems are particulate contamination and molecular contamination. Particulate contamination can consist of airborne particles, insulation shreds, clothing fibers, other human induced substances, and trapped particles in interstitial spaces, such as joints and crevices. When these particles settle on the optical surfaces, they cause degradation by obscuration and light scattering. To avoid jeopardizing the scientific objectives of the HST, the maximum percentage area coverage due to particulate contamination for the primary and secondary mirror was set at 5 percent.

PERIOD/EVENT	INCREMENT/CUMULATIVE WITH PM CLEANING
Primary Mirror Before Cleaning	2.4 / 2.4
Secondary Mirror, As Cleaned	0.1 / 0.1
Primary Mirror As Cleaned	0.7 / 0.8
Fallout During Operations	0.1 / 0.9
Transportation	0.1 / 1.0
Fallout & Chimney Effect Before Acoustic Test	1.3 / 2.3
Acoustic Test	1.3 / 3.6
Fallout & Chimney Effect	0.5 / 4.1
Rework & Storage	0.2 / 4.3
Transport & Prelaunch Operations	0.1 / 4.4
Launch	0.6 / 5.0

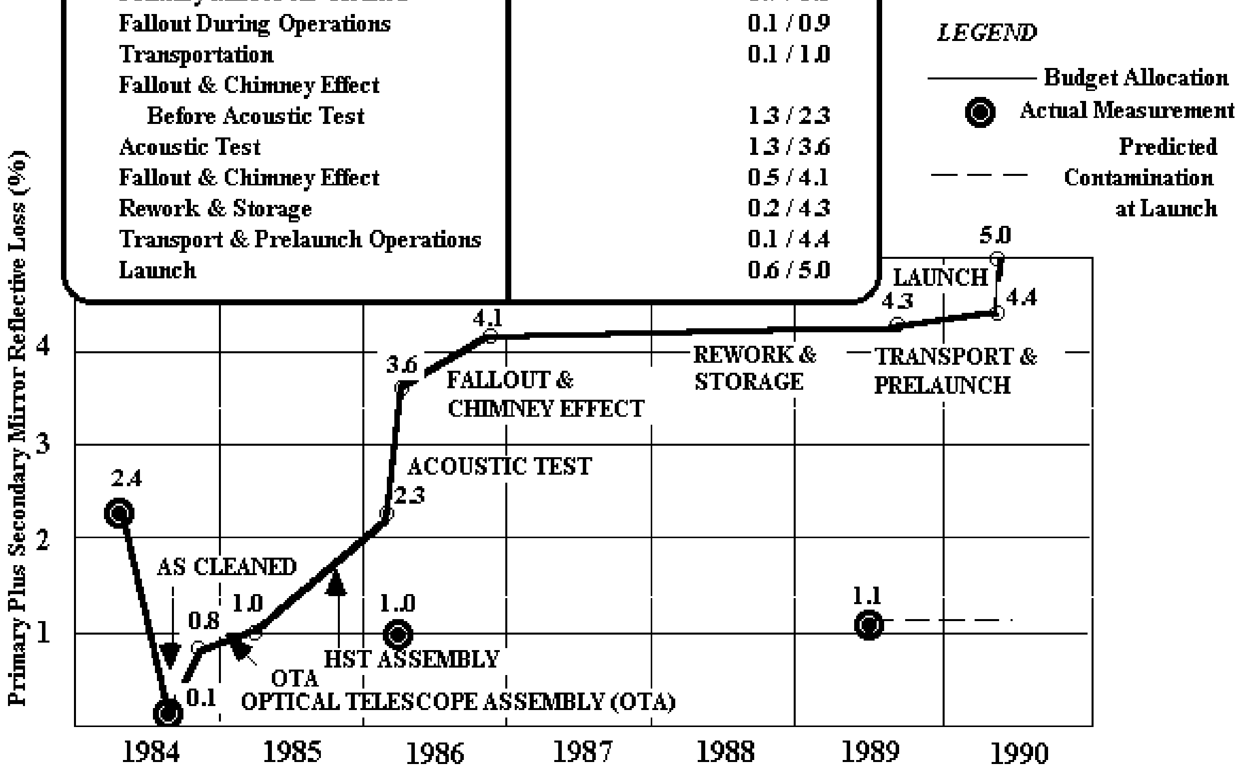

Figure 1. HST Particle Contamination Budget Allocation

Molecular contamination results from depositing outgassed products on optical surfaces, which may cause performance degradation at most wavelengths by absorbing the wave energy and/or modify polarization characteristics. Examples of molecular contaminants are lubricants, exposed organics, and volatile condensible materials. The allowed (per scientific objectives of HST) degradation due to molecular contamination dictates that the reflectance at 1216 Angstroms shall not decrease by more than 10 percent between the time of coating and five years in orbit. The operations that have the greatest potential for contamination have been allocated the larger budgets.

3. Reallocation

The requirement that limits the primary and secondary mirror area coverage total contamination budget cannot be changed. However, changes may occur in the schedule where the operational budget may have to be re-allocated. For example, in the particulate contamination budget for the HST, the original allocation of 1.35 percent assigned to pre-acoustic fallout and the chimney effect and the 1.35 percent assigned to the acoustic testing were changed to 1.30 percent. The 0.6 percent assigned to the fallout and chimney effect after acoustic testing was changed to 0.5 percent. The total of 0.2 percent obtained from these operations was assigned to the unplanned rework and storage operation.

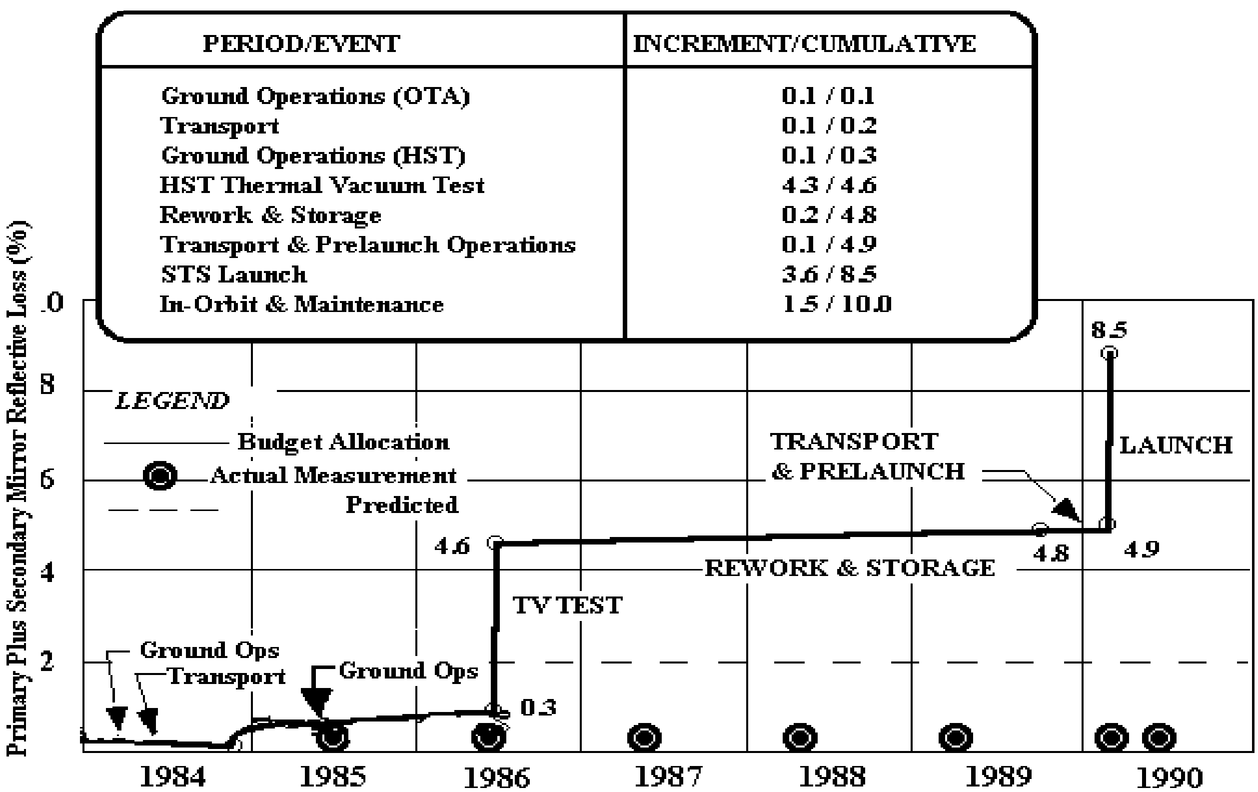

Figure 2. HST Molecular Contamination Budget Allocation

Technical Rationale:

For an optical system to achieve its desired goal of returning adequate scientific results, contamination of the optical system must be kept to a minimum. Establishing a contamination budget and controlling the contaminates within this budget ensures that the optical system will produce satisfactory scientific results.

Impact of Nonpractice:

Nonpractice could result in unacceptable degradation of the optical system with unacceptable scientific results and considerable loss of resources.

References:

1. LMSC 4176437D: "Hubble Space Telescope Contamination Control Plan," Lockheed Missiles and Space Co., Inc., (LMSC) January 30, 1987.
2. LMSC 4176594A: "Contamination Degradation Budget Allocation," ST/SE-26 Appendix A, Lockheed Missiles and Space Co., Inc., June 4, 1984.
3. LMSC 4176595C: "HST Environment Definition and Traceability," ST/SE-26 Appendix B, Lockheed Missiles and Space Co., Inc., July 13, 1990.
4. LMSC 4176596A: "HST Contamination Control Training," ST/SE-26 Appendix C, Lockheed Missiles and Space Co., Inc., November 15, 1984.
5. LMSC 4176597A: "ST Contamination Control Violation Reports," ST/SE-26 Appendix D, Lockheed Missiles and Space Co., Inc., October 30, 1984.
6. LMSC 4176598A: "ST Thermal Vacuum Bake Out," ST/SE-26 Appendix E, Lockheed Missiles and Space Co., Inc., March 31, 1988.
7. LMSC 4176599B: "HST Cleanliness Status," ST/SE-26 Appendix F, Lockheed Missiles and Space Co., Inc., August 30, 1990.
8. LMSC/F157834: "Contamination Control Implementation Plan for HST Rework and Storage," Lockheed Missiles and Space Co., Inc., November 1, 1986.
9. LMSC/D975220D: "Hubble Space Telescope, Maintenance and Refurbishment Contamination Control Master Plan," Lockheed Missiles and Space Co., Inc., June 30, 1988.
10. NASA SP-5076: "Contamination Control Handbook," National Aeronautics and Space Administration, 1969.