



Langley Research Center

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CLOSEOUT PHOTOGRAPHS FOR FLIGHT AND GROUND HARDWARE

National Aeronautics and Space Administration

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Responsible Office: Systems Management Office

Preface

P.1 Purpose

a. On March 2005, the NASA Office of Chief Engineer chartered a Digital and Closeout Photography Team led by the Policy, Assessment and Integration Department of the Safety and Mission Assurance Office at the Marshall Space Flight Center to address recommendations from the Columbia Accident Investigation Board (CAIB) and the Diaz Team related to the use of closeout photographs for flight and ground hardware actions.

b. The CAIB observations reflected a concern that NASA practices for documenting hardware closeouts and as-built configuration were not consistent, and irregularities may exist between the procedures that govern this process and actual practices. CAIB also observed that the collected photographs and related data were not formatted in a manner that facilitates ready recall of the information required to support real time decision-making processes.

c. This LPR establishes Langley Research Center (LaRC) requirements for closeout photographs. The recommendations of the CAIB/DIAZ Action Digital Closeout Photography Assessment Team and other documents were considered in developing the requirements and guidelines provided herein.

P.2 Applicability

These requirements are imposed as described herein on all projects at LaRC that develop or manage the development of reportable hardware. Reportable hardware is that which has significant functional or other mission support value and which is provided to or developed for programs and projects reporting to the Center Management Council (CMC). Hardware provided to flight projects, space flight projects, and human space flight projects are automatically reportable because those activities will be reporting to the CMC. The term "Project" is used in its generic sense and can refer to a NASA Program, Project, Subproject, or other work element.

P.3 Authority

42 U.S.C. 2473(c)(1), Section 203(c) (1) of the National Aeronautics and Space Act of 1958, as amended.

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P.4 Applicable Documents

- a. MSFC-RPT-3467, "CAIB/DIAZ Action Digital Closeout Photography Assessment Team Final Report."
- b. SSP 50486, "Preflight Imagery Requirements for NASA-Provided ISS Government Furnished Equipment."
- c. SSP 50502, "International Space Station Hardware Preflight Imagery Requirements."
- d. SPP Q-16, "Flight Closeouts and Configure for Test."
- e. LMS-CP-5505, "Flight Project Critical Milestone Review (CMR) Planning and Implementation."

P.5 Measurement/Verification

None

P.6 Cancellation

LPR 7600.1 dated March 26, 2007

Original signed on file

Cynthia C. Lee
Associate Director

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1. Requirements Overview

1.1 A graduated set of requirements and guidelines is established in subsequent sections. As the project value and/or risks increase, the project requirements become more rigorous. In this document, requirements will be enumerated in the form A.xx, where A is an alphanumeric code used to designate the tier of the requirement and xx represents the number of the requirement in that tier.

1.2 Any project that is developing or managing the development of reportable hardware shall satisfy the Tier 1 (R1.xx) requirements. The Tier 1 requirements are the most basic requirements and as such are levied on all projects that develop or manage the development of hardware.

1.3 Any project that is developing or managing the development of hardware for atmospheric flight shall satisfy the Tier 1 and the Tier 2 (R2.xx) requirements.

1.4 Any project that is developing or managing the development of hardware for space flight shall satisfy the Tier 1, the Tier 2, and the Tier 3 (R3.xx) requirements.

1.4 Any project that is developing or managing the development of human-rated space-flight hardware shall satisfy the Tier 1, the Tier 2, the Tier 3, and the Tier 4 (R4.xx) requirements.

1.5 Section 6 specifies non-binding guidelines (G.xx) that should be considered in tailoring a Photographic Documentation Plan.

1.6 Guiding Principle: DCOP is utilized to assure that the “as built” configuration can be readily identified in any troubleshooting activity. The requirements for DCOP are imposed on the Project, and by extension, the Project is to flow down the requirements to any contractors. In the rare circumstances where specific requirements may conflict with the guiding principle, the guiding principle governs.

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2. Tier 1: Requirements for all Projects developing or managing the development of reportable hardware

R1.1 The Project shall develop a Photographic Documentation Plan that describes how the requirements will be met throughout the project lifecycle. *Rationale: Developing a plan for how the photographic documentation will be done allows all the stakeholders to understand what will and will not be done. Any differences of opinion can be worked out before any crisis arises.*

R1.2 The Project shall maintain the Photographic Documentation Plan through regular updates. Current versions are required for each Project Lifecycle Review (currently called Critical Milestone Review). Modifications to the Photographic Documentation Plan are to be presented at each Project Lifecycle Review. *Rationale: If the plan is to be useful, it needs to reflect the current intentions of the project, so modifications need to be reflected in changes to the plan. To ensure stakeholder understanding of the changes, significant changes need to be presented at each Project Lifecycle Review.*

R1.3 The Project shall tag DCOP files with searchable metadata to facilitate retrieval of desired images. The metadata supports cataloging and retrieval of the image by search criteria. Consistent vocabulary is used for the metadata. An electronically available glossary defines any ambiguous terms used to describe hardware. *Rationale: For the photographs to be useful, they need to be catalogued with appropriate data that facilitates finding them and related information.*

R1.4 The Project shall specify the format of the photographs. It is preferred that still imagery be provided as a digital still Tagged Image Format (TIF) or Joint Photographic Equipment Group (JPEG) file. *Rationale: A common file format facilitates use by all the stakeholders.*

R1.5 The Project shall specify the backup protocol for the photographic system. *Rationale: In the event of a system failure, it is desirable to be able to recover the photographs and their metadata.*

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3. Tier 2: Additional requirements for Projects developing or managing the development of hardware to be flown

R2.1 The Project shall develop and maintain a list of critical items and configurations that require DCOP. During the design phase, an initial list is developed of the critical items that require DCOP during manufacture, integration, and test. The list specifies at what stage or stages in the process photo(s) are to be taken. The original list is required for the Preliminary Design Review and is amended through a subsequent review of anomalies reported during manufacture, integration, test, and operational deployment of the items. The list of required DCOP items is reviewed and updated at every subsequent Project Lifecycle Review (currently called Critical Milestone Review). *Rationale: Maintaining a list mitigates the chance that important photographs will be forgotten. Reviewing the list at design and readiness reviews provides some oversight of the list.*

R2.2 The Project shall integrate DCOP tasks into manufacturing processes. If photographs are required at a particular point in the manufacturing process, subsequent steps in the manufacturing process are not to be executed until the photographs are taken or a waiver of the photographs is obtained. The DCOP is to be included in the build documentation (e.g. work authorization document). *Rationale: If particular photographs have been required (i.e., are on the list developed according to R2.1), then taking those photographs at the appropriate manufacturing stage is critical to obtaining the desired collection of photographs. Continuing with manufacturing without taking the required photograph(s) leaves gaps in the photographic collection (and therefore the artifacts that would be available for hardware review) that cannot be filled later.*

R2.3 The Project shall conduct informal engineering reviews of DCOP taken of critical items to ensure satisfaction of the technical reasons for taking the photo. The review ensures the quality of the photographs (e.g., resolution, focus, illumination), the sufficiency of the views, and the sufficiency of auxiliary information (e.g., scale objects in the photograph, metadata). *Rationale: Engineering review of the photographs helps ensure that the photographs are usable for their desired intent. The review may also uncover discrepancies or deficiencies in the as-built hardware.*

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4. Tier 3: Additional requirements for Projects developing or managing the development of hardware to be flown in space

R3.1 The Project shall ensure that the list of critical items that require DCOP (see requirement R2.1) includes the following:

- a. Any waiver or deviation action that changes the “as built” configuration
- b. Any “Remove before flight” hardware
- c. Any adjustable hardware component (e.g., switches, valves)
- d. Any Quick Disconnects (QDs) and connectors
- e. Views before and after external blankets, insulation, or other obscuring layers are applied. (This applies for blankets, insulation, or other obscuring layers that will either be removed or maintained during operation.)
- f. Any decals and other markings

Rationale: The required list addresses many of the critical items that eventually lead to uncertainty as to the as-built configuration.

R3.2 The Project shall implement management controls to ensure that documented DCOP procedures are followed. The management controls may include random spot checks to ensure that the procedures described in the Photographic Documentation Plan are being followed. Corrective actions are required for any discrepancies between the documented and actual procedures. *Rationale: For space-flight projects, the potential harm to the Project for not following the Project’s DCOP procedures is large enough to warrant the addition of controls to ensure implementation of the DCOP procedures.*

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5. Tier 4: Additional requirements for Projects developing or managing the development of human-rated space-flight hardware

R4.1 The Project shall develop a dual system for the storage and retrieval of DCOP. The primary system is to be capable of retrieving any photograph (including metadata) within 2 minutes. In the event of failure of the primary DCOP system, the secondary system is to be capable of retrieving any photograph (including metadata) within 30 minutes. The time limits here refer to the time required for a computerized search and retrieval including the mounting of any storage media, but do not include human time requirements for initiating the search and determining the appropriateness of the retrieved photographs for the intended purpose. *Rationale: For human-rated space-flight hardware, determining the as-built configuration quickly can be important for crew survival.*

R4.2 The Project shall conduct engineering reviews of DCOP as required by R3.1 with the additional requirement that at a minimum, the following criteria are used to determine the sufficiency of the photographs:

R4.2.1 Where possible, at least one photograph of the object being imaged will have the longest dimension perpendicular to the optical axis of the camera (i.e., along the image plane). *Rationale: The longest dimension needs the most pixels to image it as thoroughly as the other dimensions.*

R4.2.2 At least one photograph of the object being imaged will include a scale placed in the field of view near the item being imaged. The preferred orientation of the scale is along the longest dimension of the object being imaged. *Rationale: The inclusion of a scale provides some means for estimating sizes.*

R4.2.3 For integration imagery, coverage includes:

- a. A wide view of the location
- b. A normal view of item(s) of interest in their surrounding area
- c. Close-up views of all end items and other item(s) of interest with special emphasis on items such as lower structure, fluid lines, gaseous lines, wire harnesses, wire identifications, reference designators, couplings, feed-throughs, connectors, and clamps (where applicable).

Rationale: The wide view facilitates seeing the big picture; the normal view puts the individual elements in context; and the close-up views provide details of items that often provide interfaces between components.

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6. Guidelines to be considered in developing a Photographic Documentation Plan

G.1 Ideally the Project conducts studies to determine a specified minimum digital photographic capability to meet resolution requirements. The requirement may change for each item.

G.2 If the Project determines that motion imagery is required, the Project should specify the desired recording resolution and format. Video formats that exceed 400 lines of horizontal resolution with time coding are preferred.

G.3 Where appropriate, the following hardware components are good candidates for hardware to be included in the list of critical items requiring DCOP (see requirement R2.1):

- a. As-installed hardware to show all visible connectors, fittings, attachment fasteners, reference designators, thermal cooling interfaces, and filters
- b. All fluid/gas lines and electrical/data harnesses as-installed to show all visible fittings, couplings, connectors, and reference designators
- c. All mating/assembly interfaces of hardware
- d. Each area to show systems hardware accessibility
- e. All closeout panels and covers to show attachment fasteners and all nomenclature (e.g., labels, placards)
- f. Overall and close-up views of system hardware
- g. All manual crew interfaces - e.g., panels, hatches, valves
- h. Printed circuit boards to confirm component placement, types, values, and board coatings

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7. Waivers

- a. Waivers to any requirements of this LPR can be granted by the LaRC Chief Engineer or his/her designee. Any approved waivers shall be approved in writing.
- b. Waivers shall be granted only upon written request from the manager of the Project (or element thereof).
- c. Any requests for waivers shall be accompanied by evidence of concurrence by the relevant Lead Systems Engineer and the Project sponsor (the Principal Investigator or other appropriate person).
 - (1) In cases where the identity of the Lead Systems Engineer and the Project sponsor are unclear, the LaRC Chief Engineer or his/her designee may assign individuals to act in those roles or may waive the requirement for concurrence.
- d. All waiver documentation shall be maintained by the Project.

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Appendix A: Definitions

A1. Atmospheric Flight: Flight of a vehicle, instrument, or other hardware up to an altitude of 100 km above the earth's surface.

A2. Close-up View: An image that contains details of the object of interest.

A3. Digital Close-Out Photograph (DCOP): A digital image of a subsystem or interface taken to document hardware configuration at the completion of manufacture/assembly, or following final test and/or pre-launch preparation.

A4. Normal View: An image capturing the object of interest and the relevant surrounding area.

A5. Reportable Hardware: Hardware that has significant functional or other mission support value and which is provided to or developed for programs, projects, or other activities reporting to the Center Management Council (CMC).

A6. Space Flight: Flight of a vehicle, instrument, or other hardware above an altitude of 100 km above the earth's surface.

A7. Wide View: An image capturing the general orientation of the object(s) of interest in relation to the element/module/end item.