Subject: Photographic Documentation of Hardware

Responsible Office: Safety and Mission Assurance Office

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Preface

P.1 Purpose

This Langley Procedural Requirement (LPR) establishes Langley Research Center (LaRC) requirements for closeout photographs. Only spaceflight projects were deemed to be at sufficient risk for imposing requirements in this area. The bulk of this document is guidance.

Individuals are reminded that photographs (even without accompanying explanatory information) might be export controlled or otherwise sensitive. When that is the case, the relevant photographs are subject to applicable rules, laws, and procedures.

P.2 Applicability

a. These requirements are imposed on LaRC-managed spaceflight projects, i.e., those projects involved in launching hardware into Earth orbit or outside of Earth's gravitational influence. The content of this document is recommended to all other projects. The term "Project" is used in its generic sense and can refer to a NASA Program, Project, Subproject, or other work element.

b. In this directive, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms "may" denotes a discretionary privilege or permission, "can" denotes statements of possibility or capability, "should" denotes a good practice, and is recommended, but not required, "will" denotes expected outcome, and "are/is" denotes descriptive material.

c. In this directive, all document citations are assumed to be the latest version, unless otherwise noted.

P.3 Authority

a. National Aeronautics and Space Act, 51 U.S.C. §20113.

b. NPR 7123.1, NASA Systems Engineering Processes and Requirements.

c. LPR 5300.1, Product Assurance Requirements.

P.4 Applicable Documents and Forms

a. SSP 50502, International Space Station Hardware Preflight Imagery Requirements.

b. SSP 50521, Return, Processing, Distribution and Archiving of Imagery Products from the International Space Station.

c. LF 236, Shipping Inspection Instructions for Flight and Ground Support Hardware.

d. LF 532, Receipt and Inspection Report (R & IR) Flight Hardware.

P.5 Measurement/Verification

None

P.6 Cancellation

LPR 7600.1 C, dated January 22, 2016

/s/ David Young November 27, 2022

Deputy Director Date

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CHAPTER 1: Photographic Documentation

1.1 Photographic Documentation Plan

1.1.1 Each spaceflight Project shall develop a Photographic Documentation Plan that addresses each of the recommended practices described in this LPR. The plan describes Project practices that are used to photographically document the as-built flight hardware in ways that would be helpful to any future troubleshooting activity. The plan shall be in preliminary form at the Preliminary Design Review (PDR) (or Project equivalent) and to be baselined for the Critical Design Review (CDR) (or Project equivalent). The Photographic Documentation Plan is updated as needed throughout the rest of the Project lifecycle. The Photographic Documentation Plan may be included as a section of an appropriate larger document.

1.1.1.1 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. The timing for the preliminary and baseline version is consistent with the typical timing for developing flight hardware.

1.1.1.2 The plan shall identify which LaRC organization is responsible for taking the photographs and the photo equipment to be used. The Project should fund and provide training for any special equipment required for this activity.

a. Project engineers and technicians will take photographs for the Project during the assembly, integration, and test processes.

b. Quality Assurance (QA) personnel shall take photographs for Langley Form (LF) 532s and may take photographs for LF 236s, the *E2* fabrication workorder system photographs, and Non-Conformance Report (NCR) photographs, as required.

1.1.1.3 The Plan shall be approved by the Project Manager.

1.1.1.4 The Configuration Manager will identify and create a digital repository (e.g., SharePoint) in which the Project photographs will be stored.

1.2 Recommended Practices for All Projects Developing or Managing the Development of Hardware

1.2.1 The Project should determine from its customers, partners, and key stakeholders any photographic requirements with which the Project needs to comply.

1.2.1.1 Rationale: Different organizations may impose different requirements for photographing hardware that interacts with their systems. For instance, SSP 50502 specifies pre-flight imagery requirements for hardware connecting to the International Space Station (ISS). SSP 50521 details the disposition of imagery taken from the ISS.

1.2.2 The Project should develop and maintain a list of critical items, configurations, and processes that require photographs. During the design phase, an initial list is developed. The original list is developed for the Preliminary Design Review and is amended as necessary at every subsequent Project Lifecycle Review.

1.2.2.1 Rationale: Maintaining a list lessens the chance that important photographs are forgotten. Reviewing the list at design and readiness reviews provides opportunities for outside input to the list.

1.2.3 The Project should integrate photographing into the assembly, integration, and test processes. If photographs are required at a particular point in the process, subsequent steps in the process or procedure should not be executed until the photographs are taken. The photographs should be included in the build documentation (e.g., work authorization document).

1.2.3.1 Rationale: Taking 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 that cannot be filled later.

1.2.4 The Project should tag photographic 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.

1.2.4.1 Rationale: For the photographs to be useful, they need to be catalogued with appropriate titles that facilitates finding them and related information.

1.2.5 The Project should 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.

1.2.5.1 Rationale: A common file format facilitates use by all the stakeholders.

1.2.6 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.

1.2.6.1 Rationale: Appropriate spatial and temporal resolution of the video image is necessary for capturing visual items of interest.

1.2.7 Photographs should include a scale reference item or specify appropriate reference dimensions in accompanying metadata.

1.2.7.1 Rationale: Scale objects provide a sense of size in the photograph. When a scale object is not included, the dimensions of an object in the photograph can serve as a useful substitute.

1.2.8 Where possible, at least one photograph of the object being imaged should have the longest dimension perpendicular to the optical axis of the camera (i.e., along the image plane).

1.2.8.1 Rationale: The longest dimension needs the most pixels to image it as thoroughly as the other dimensions.

CHAPTER 2: Photographs for Space Flight Projects

2.1 Recommended Practices for Spaceflight Projects

2.1.1 The Project list of items or steps in a process that require photographs should include the following:

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. Systems hardware accessibility areas.

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 interfaces (e.g., panels, hatches, valves, handles).

h. Printed circuit boards to confirm component placement, types, values, and board coatings.

i. Any waiver or deviation action that changes the “as-built” configuration.

j. Any “Remove Before Flight” hardware (photographed before and after removal).

k. Any adjustable hardware component (e.g., switches, valves) in final configuration.

l. Any Quick Disconnects and connectors.

m. 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.)

n. All labeling.

2.1.2 Rationale: The above list includes many of the critical items that may need to be checked through the use of photographs at a later time.

2.1.3 For hardware that requires in-space assembly or integration, the Project list of critical items that require photographs should include the following:

a. All mating interfaces of the hardware that require assembly or integration.

b. All robotics and manual interfaces (e.g., grapple fixtures, grasp fixtures, and targets).

c. All robotic mating interfaces (e.g., alignment hardware, attachment hardware, electrical connectors), including both halves of mating interfaces.

d. All visual cues and alignment markings intended for use during assembly or integration.

e. Full views of the outer mold line of any hardware to be assembled or integrated.

f. Full views of crew and/or robotically actuated moving parts. Image each initial, final, and operationally significant intermediate position of movable hardware.

2.1.3.1 Rationale: The above items provide information that may be critical during in-space assembly or integration, especially if an anomaly occurs and the process deviates from plan.

2.1.4 For hardware that requires in-space assembly or integration, the imagery coverage should include:

a. A wide view.

b. A normal view of item(s) of interest and their surrounding area.

c. Close-up views of all end items and other item(s) of interest with special emphasis on items such as fluid lines, gas lines, wire harnesses, wire identifications, reference designators, couplings, feedthroughs, connectors, and clamps (where applicable).

2.1.4.1 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.

2.1.5 If hardware is associated with the ISS, the Project should refer to SSP 50502.

2.1.5.1 Rationale: SSP 50502 prescribes imagery requirements for hardware associated with the ISS, including external science payloads. While many of those requirements are generically included in the guidance provided here, SSP 50502 provides specific requirements for such hardware.

2.1.6 The Project should evaluate photographs taken of critical items to ensure satisfaction of the technical reasons for taking the photo. The evaluation 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).

2.1.6.1 Rationale: Evaluation of the photographs helps ensure that the photographs are usable for their desired intent. The evaluation may also uncover discrepancies or deficiencies in the as-built hardware.

2.2 Recommended Practices for Projects Developing or Managing the Development of Human-Rated Spaceflight Hardware

2.2.1 The Project should develop a dual system for the storage and retrieval of photographs. The Project should work with the customer of the hardware to determine appropriate time frames for retrieving any photograph (including metadata) from the primary and secondary systems.

2.2.1.1 Rationale: For human-rated spaceflight hardware, determining the as-built configuration quickly can be important for crew survival.

2.2.2 The Project should implement management controls to ensure that documented photographic 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.

2.2.2.1 Rationale: For human spaceflight projects, the potential harm to the Project for not following the Project's photographic procedures is large enough to warrant the addition of controls to ensure implementation of those procedures.

APPENDIX A. ACRONYMS

CDR	Critical Design Review
ISS	International Space Station
JPEG	Joint Photographic Equipment Group
LaRC	Langley Research Center
LF	Langley Form
LMS	Langley Management System
LPR	Langley Procedural Requirements
NASA	National Aeronautics and Space Administration
NCR	Non-Conformance Report
PDR	Preliminary Design Review
QA	Quality Assurance
SMAO	Safety and Mission Assurance Office
TIF	Tagged Image Format