Large Synoptic Survey Telescope	Document # **LCA-00138-B**		Status LSST Camera APPROVED Effective Date: 18 Sept 2014
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	Subsystem/Office Project Management, Performance and Safety Assurance, Systems Integration		
Document Title **LSST Camera Performance and Safety Assurance Plan**			

1. Change History Log

Revision	Effective Date	Description of Changes
A	April 23, 2013	Baseline release of document Reviewed under LCN-1035.
B	Sept 18, 2014	Revised and updated for CD-2 Review. See LCN-1131; Miscellaneous editorial corrections 3. Acronyms: removed uncited acronyms; 4. Applicable Documents: [14] LCA-10098 and [15] LCA-10099 were TBD document numbers (also fixed references in document); removed Ref. [19]—Reliability Plan is cancelled and contents have been included in other documents; 6. Management: updated Figure 1 Org Chart; updated Figure 2 Plans and Standards chart; Quality Assurance Manager was Performance Assurance Manager; Safety Officer was Safety Engineer; clarified that Safety Officer is appointed by ALD; added roles and responsibilities for Safety Officer; 9. ES&H Assurance: removed reference to SLAC experimental project review process, which has been eliminated; 12. Reliability Assessment: re-wrote to point to Ref.'s [13] and [14] for details on implementing controls to assure adequate reliability;

2. Contents

3. Acronyms

ALD	Associate Laboratory Director
CPM	Camera Project Manager
DOE	Department of Energy
EEE	Electrical, Electronic, and Electro-mechanical
ESD	Electro-Static Discharge
ES&H	Environment, Safety, and Health
FDR	Final Design Review
IQIP	Institutional Quality Implementation Plan
ISIP	Institutional Safety Implementation Plan
LSST	Large Synoptic Survey Telescope
MRR	Manufacturing Readiness Review
MTBF	Mean Time Between Failures
NCR	Non-Compliance Report
PFR	Problem/Failure Report
PPA	Particle and Particle Astrophysics Directorate at SLAC
PSA	Performance and Safety Assurance
PSAP	Performance and Safety Assurance Plan
QA	Quality Assurance
QC	Quality Control
QIP	Quality Implementation Plan
SEMP	System Engineering Management Plan
SIM	Systems Integration Manager
SLAC	SLAC National Accelerator Lab
SOP	Standard Operating Procedure
S/CI	Suspect/Counterfeit Item
TBD	To Be Determined
TBR	To Be Resolved
TRR	Test Readiness Review
WP&C	Work Planning and Control

4. Applicable Documents

[1] LCA-227, “LSST Camera Quality Implementation Plan”

[2] DOE-O414.1D, “Quality Assurance”

[3] LPM-18, “LSST Safety Plan”

[4] LCA-38, “LSST Camera System Engineering Management Plan”

[5] LCA-226, “LSST Camera Project Management Plan”

[6] LCA 98, “Camera Design Review Plan”

[7] SLAC-I-720-0A29Z-001-R023, “SLAC Environment, Safety, and Health Manual”

[8] LCA-31, “LSST Camera System Safety Program Plan”

[9] LCA- 14, “Preliminary Hazard Analysis”

[10] LCA 15, “Camera Hazard List”

[11] LCA-139, “Camera Hardware Protection Plan”

[12] LCA-140, “Camera Hardware Protection Protocol List”

[13] LCA-280, “Camera Mechanical Standards”

[14] LCA-10098, “Camera Electronics Standards”

[15] LCA-10099, “Camera Software Standards”

[16] LCA-279, “Contamination Control Plan”

[17] LCA-278, “Grounding and Shielding Plan”

[18] LCA-10032, “Electro-Static Discharge Control Plan”

[20] LCA 39, “LSST Camera Configuration Management Plan”

5. Purpose and Scope

This Performance and Safety Assurance Plan (PSAP) details the performance and safety assurance programs described in Ref. [1], the “Camera Quality Implementation Plan” (QIP), including the programs needed for the Camera project to be in compliance with Ref. [2], DOE Order 414.1C as well as Ref. [3], the “LSST Safety Plan.”

Specifically, the scope of this Plan includes the Camera system safety program, environment, safety, and health (ES&H) plans and the means by which personnel and environmental safety processes are managed across the camera collaboration, and the quality management system for the project. The Plan includes, by reference, lower-tier Plans and Standards called out here.

This PSAP and Ref. [4], the “Systems Engineering Management Plan” (SEMP) detail the processes used to technically manage the LSST Camera project. They are referred to by Ref. [5], the Camera Project Management Plan.

6. Performance and Safety Assurance Management

6.1. Camera Organization and Management

The LSST camera team consists of members from geographically diverse organizations and is managed by the Camera project office at the SLAC National Accelerator Lab (SLAC). The Camera organizational structure is shown in Figure 1. The Camera Project Director provides overall project direction and interface to the LSST project, while the Camera Project Manager (CPM) has responsibility for day to day execution of the project. The Camera project scientist provides the primary technical oversight of camera science performance and is the focal point for coordination of science requirements with the LSST Observatory science team. The CPM is supported by the Camera Systems Integration Manager (SIM) and the Performance and Safety Assurance (PSA) office in the execution, technical oversight and coordination of the Camera development, construction and commissioning activities. Camera Subsystem Managers report to the project manager, with the SIM and PSA managers providing technical support and oversight.

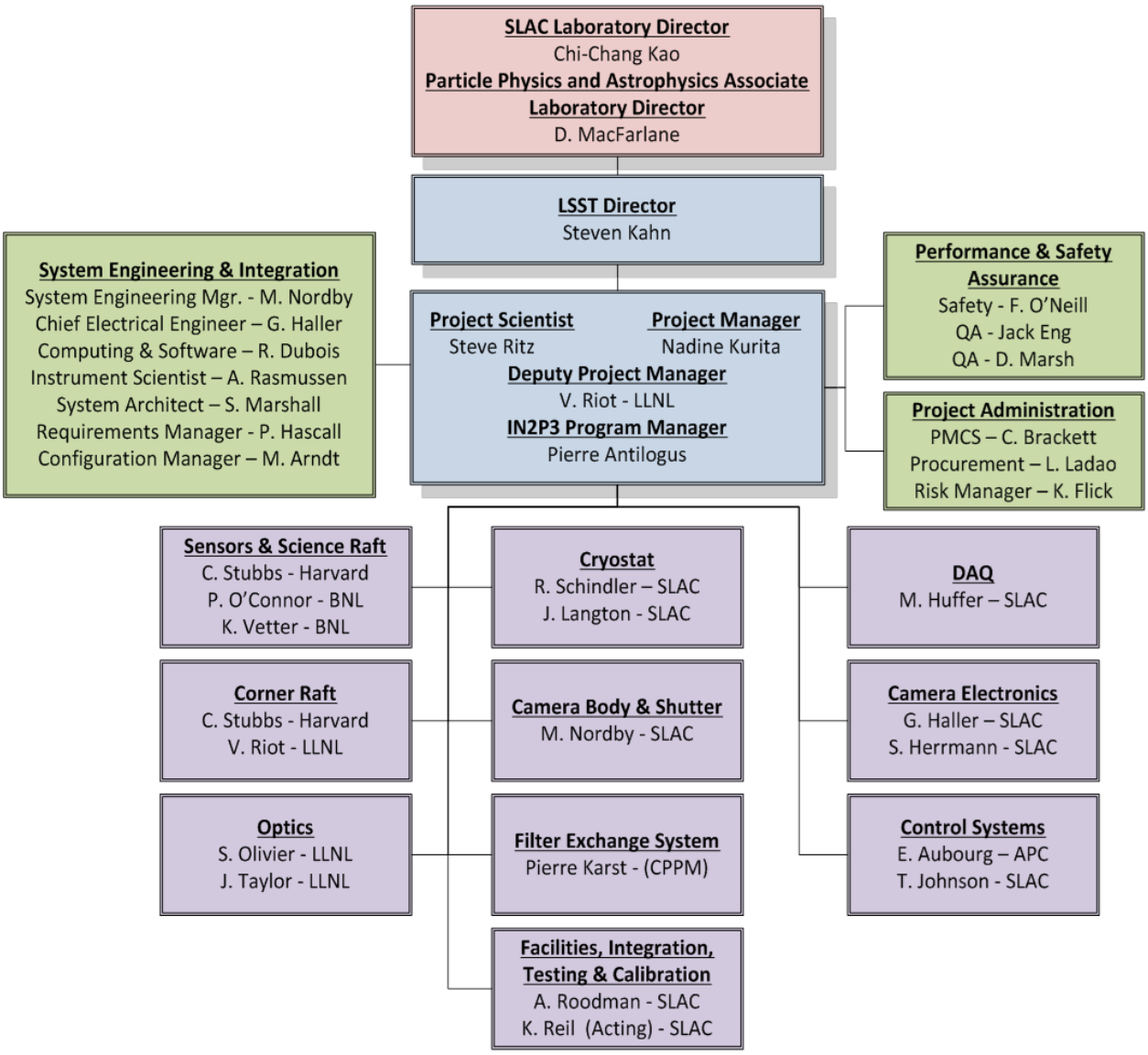

Figure 1: Camera Project Organization

The Camera is one of three subsystems of the LSST Observatory. As such, the CPM reports to the LSST project office. Management and system safety processes formally flow down along this channel. However, the Camera management works closely with counterparts in the LSST project to ensure that the Camera processes integrate closely with those of the rest of the Observatory. The camera is managed through application of processes described by a hierarchy of management and implementation plans, as shown in Figure 2. This document is one of three that define these plans explicitly or by reference to lower-level plans and standards.

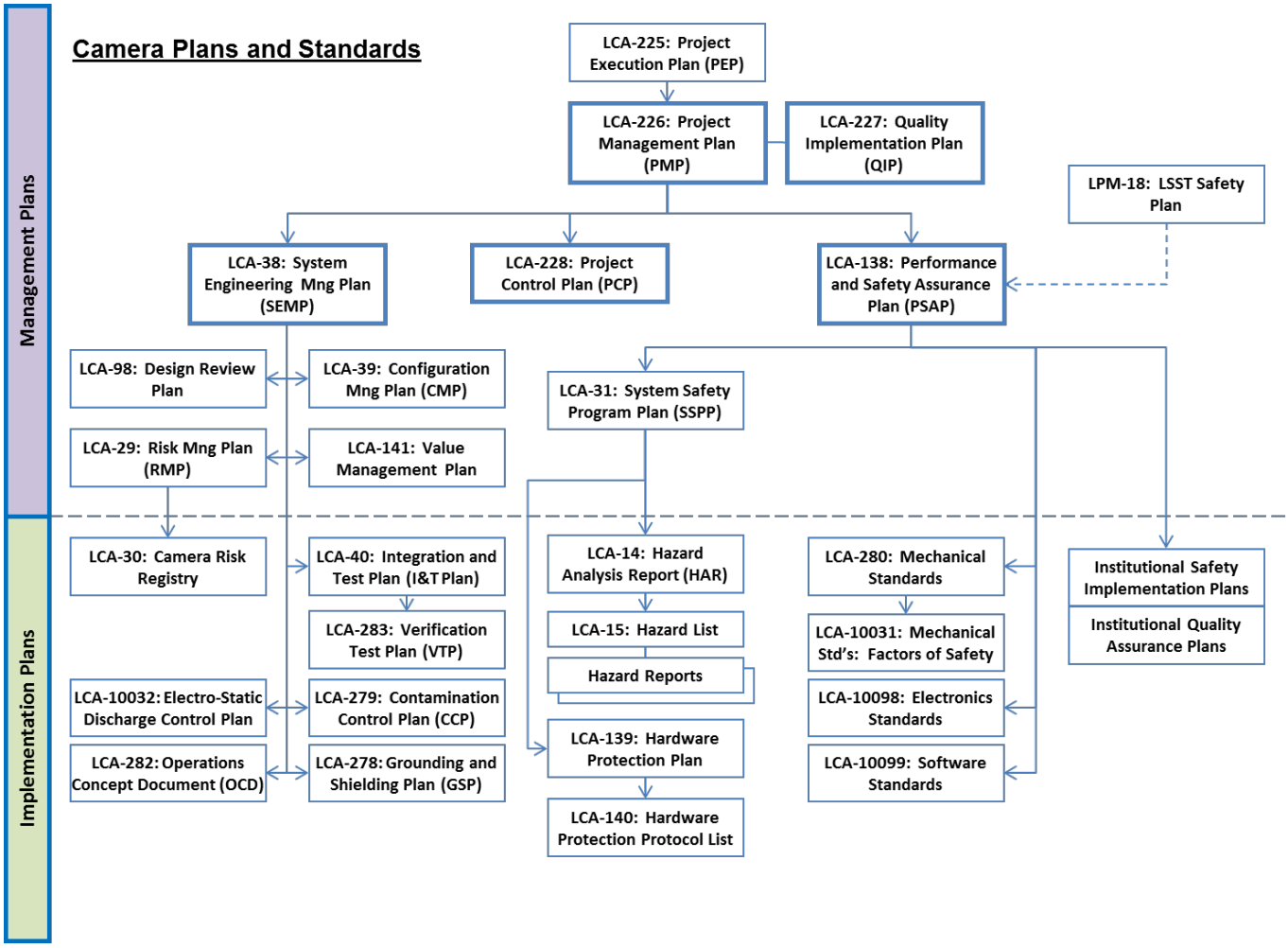

Figure 2: Camera project management planning documentation

The camera collaboration is composed of institutions around the country and in France. Despite their geographical spread, the project is managed as a single project, with subsystem managers and technical personnel at collaborating institutions reporting to the project manager and expected to follow the plans, standards, and processes laid out by the project manager. Ref. [5], the "LSST Camera Project Management Plan," lists the institutions involved and their role in the project.

In parallel with the project management organization, camera work at each institution is led and supervised by an institutional lead. Often, this is the same person as the manager, but not necessarily. Institutional leads provide the single point of reference between the project work and the institutional management chain. Key institutional personnel support them to implement local environment, safety and health regulations and policies, as well as quality assurance support and other project management support.

In general, all processes and requirements laid out in this plan are expected to be fulfilled through flow of Camera project responsibility and authority. Thus, subsystem managers at collaborating institutions fulfill all aspects of this plan as it relates to their subsystem. However, some aspects of this Plan are fulfilled through institutional policies, processes and directives. Furthermore, local institutional requirements may levy further requirements on Camera subsystem work processes beyond those defined in this Plan. For ES&H and system safety topics, Section 9.2 establishes the institutional safety assurance plans, which clearly define how local ES&H programs are used in fulfilling the requirements

laid out in this Plan. Likewise, Section 10.2 establishes the institutional quality assurance plans to identify local QA policies and procedures to be used to fulfill the directives in this Plan.

The following section identifies key project and institutional positions and their roles and responsibilities.

6.2. Roles and Responsibilities

6.2.1. Camera Project Manager

The Camera Project Manager has overall project management authority. The CPM is responsible for project planning, for achieving project scope, performance, and quality objectives on schedule within the approved budget, for compliance of all ES&H procedures, and for coordinating the activities of the project. In addition, the CPM approves staffing plans and actions.

The Project Manager also approves all management plans and implementing procedures, including this document. Other responsibilities and duties of the CPM are described in the Ref [5], the "LSST Camera Project Management Plan."

6.2.2. Quality Assurance Manager

The Quality Assurance Manager reports directly to the CPMand is responsible for:

Maintaining this PSAP and referenced documents that form a part of the quality program

Providing consultation to the CPM and Subsystem Managers in implementing established QA procedures and policies (e.g.: developing subsystem or institutional vendor control programs, establishing review procedures)

Providing or coordinating project-specific QA training for project members

Coordinating completion of QA-related milestones as provided in project schedules

Working with the CPM and Subsystem Managers to avoid situations where completion of critical planned QA activities are compromised due to cost, schedule or other constraints

Recommending to the CPM that work be stopped based on an investigation that indicates that work is of inadequate quality

Performing QA audits as requested by the CPM

Participating individually or as part of a team in vendor surveys, vendor qualifications, and source inspections

Working with institutional QA representatives to establish the Institutional Quality Implementation Plan (IQIP), ensure that local programs are in place, and audit the programs as needed through the life of the project.

6.2.3. Safety Officer

The Safety Officer reports directly to the CPM, with an appointment by the SLAC Associate Laboratory Director (ALD) for Particle and Particle Astrophysics (PPA). The Safety Officer is the focal

point for all safety activities involved in implementing the Camera PSAP. The Safety Officer influences the design when necessary in the interest of safety, and with the goal of minimizing the overall hazard level of the camera design and operations. This requires that the Safety Officer is actively involved in many aspects of the project. The Safety Officer is responsible for:

- Maintaining this PSAP and referenced documents that form a part of the ES&H and system safety program
- Providing consultation to the CPM and Subsystem Managers in implementing established ES&H and system safety procedures and policies.
- Stopping any work that indicates inadequate consideration for personnel or system safety or impact on the environment.
- Participating as a member of the LSST Safety Council
- Participating in design reviews
- Preparing the system safety program deliverable documents
- Supporting the LSST system safety program implementation and providing the primary interface to the Camera
- Developing and establishing safety design criteria and safety design requirements as needed
- Reviewing and approving selected drawings, specifications, and procedures
- Participating in hazardous testing and system safety testing
- Evaluating design changes for their impact on safety
- Providing oversight and direction to institutional safety officers at all collaborating institutions, including developing Institutional Safety Implementation Plans (ISIP's), ensuring that procedures and work processes are implemented as deemed necessary, and auditing the ES&H and system safety programs at collaborating institutions as necessary.
- Serving as SLAC institutional safety officer, overseeing all Camera work at SLAC

6.2.4. Systems Integration Manager

The Systems Integration Manager provides technical leadership and directs the work of the subsystem development teams through the development and tracking of requirements, allocations, interface control documents, and performance and verification specifications. The SIM is responsible for assuring that the subsystems are compatible and meet their overall objectives. The SIM also oversees, from the camera side, all aspects of camera-telescope and camera-data management interfaces, as well as flow-down of LSST system-level requirements.

The SIM is responsible to implement all programs defined in Ref. [4], the "Camera System Engineering Management Plan,", and ensure that they are being used through subsystem management. This includes configuration management, review processes, requirements and interface management, and risk analysis.

6.2.5. Subsystem Managers

Camera Subsystem Managers or their designee are responsible for integrating the safety and quality assurance programs defined in this plan into their subsystem processes. This includes directly supporting

ES&H, system safety, and QA activities at the institution. They are supported by the QA Manager, Camera Safety Officer and Systems Integration Manager, but are ultimately responsible for their subsystem, regardless of the institution or subsystem.

6.2.6. Institutional Safety Officer

The Institutional Safety Officer provides support for institutional line management to ensure that the institutional plans and processes called out in the ISIP are implemented in the execution of Camera work at that institution. The Institutional Safety Officer may report directly to the line management responsible for Camera work at the institution or to higher-level ES&H officials, depending on the organization's management structure. They are also responsible to work with the Camera SE to ensure that local processes meet camera requirements, as well as with institutional subject matter experts, building and area managers, and other personnel that support or oversee Camera work at the institution.

6.2.7. Institutional Quality Assurance Officer

The Institutional Quality Assurance Officer provides support to either the Camera institutional lead or subsystem manager to ensure that institutional QA policies and processes called out in this document are implemented in the execution of Camera work at that institution. The QA officer is responsible to work with the Camera QA Manager to ensure that local processes meet camera requirements, as well as with institutional personnel that support or are involved with Camera work at the institution, including purchasing officers, inspection or test departments, building managers, facilities personnel involved in building monitoring, security, and any other groups whose work or support impacts Camera work quality.

6.2.8. Institutional Point of Contact

The local point of contact is responsible for training and managing the work of sub-contractors or collaborators working on site. This includes defining the training needed, both to comply with institutional safety requirements and to safely work around and on camera equipment. See Section 17 for further details on defining training requirements.

6.3. Program Monitoring and Assessment

The Camera project performance and safety assurance program plans and processes are reviewed through four tiers of reviews over the life of the project. These are described below.

6.3.1. Camera DOE Program and Status Reviews

The DOE Critical Decision review process includes assessment of the Camera performance and safety assurance program, especially as it relates to the management of the camera. See Ref. [5] "LSST Camera Project Management Plan" for details of these reviews. DOE also conducts 'status' reviews regularly,

focusing on specific elements of the performance and safety assurance program, as necessary.

6.3.2. Camera Technical Reviews

Camera subsystems are subject to technical design reviews as part of the project management process. These reviews include external reviewers to provide independent assessment and feedback for the Camera Project Manager. Technical reviews include subsystem plans to address hazards, personnel safety, and assurance and work process control plans to ensure that subsystem requirements are met. See Ref. [6], LCA-98, "Camera Design Review Plan" for review criteria, minimum content, and processes. Review committees for all such reviews include either the Safety Engineer or his representative, as well as quality assurance personnel if deemed necessary.

6.3.3. Camera Assessments

As part of preparations for production of Camera hardware, subsystems are subject to assessments specifically intended to evaluate manufacturing and test plans and processes, including implementation of safety and quality assurance processes. The Manufacturing Readiness Reviews (MRR) and Test Readiness Reviews (TRR) include assessment of the work processes planned to be used, as well as assurance plans that are used during the production or test process. All such assessments include safety and QA representatives, as well as any subject matter experts deemed necessary to adequately assess subsystem plans. See Ref. [6] for review criteria, minimum content, and processes.

Additional assessment and audits are scheduled in support of the production and test work as deemed necessary by Camera management or the QA Manager.

7. Stop Work Authority

7.1. Relating to Work of Inadequate Quality

Any individual involved in the project who becomes aware of an activity or workmanship that he or she believes to be of inadequate quality should bring the condition(s) to the attention of the their supervisor. It is the responsibility of the supervisor to investigate the condition(s) believed to be of inadequate quality, to communicate the problem to the Project Manager, and to take appropriate corrective actions based on the condition(s). Project Manager has the authority to stop work of inadequate quality if deemed appropriate. The role of the QA Manager with respect to making recommendations to stop work of inadequate quality has been previously described in Section 6.2.2.

7.2. Relating to Hazardous Operations or Conditions

The policy on stop work authority relating to hazardous operations or conditions is provided in Chapter 1 of Ref. [7], the "SLAC ES&H Manual." This policy is interpreted to include stop work authority for any project supervisor or any member of the project team. Issues relating to stop work based on potentially hazardous operations or conditions shall be communicated to the Camera Safety Officer or institutional safety officer.

8. System Safety Program

The LSST Camera system safety program has been implemented to identify system hazards, manage them during the life of the project, and mitigate their impact through appropriate design or administrative controls. This program is described in Ref. [8], LCA-31, "LSST Camera System Safety Program Plan," and is managed by the Safety Officer for the Camera Project Manager. The system safety program involves a three step process for identifying, ranking, managing, and mitigating hazards associated with the operation of the camera.

First, camera functionality and hazardous conditions are described in Ref. [9] LCA- 14, the "Preliminary Hazard Analysis" document. This describes the functional elements of the camera and hazards associated with them.

Second, hazards are explicitly identified and ranked in Ref. [10] LCA 15, "Camera Hazard List." Here, hazards, causes and impacts are discretely identified along with expected probability of occurrence and impact on the camera if the hazard came to pass. This list provides a straightforward method for identifying and tracking hazards through the design development and manufacturing process.

Third, for select hazards which have significant impact, higher probability of occurrence, or complex mitigation plans, Hazard Reports are developed to better define the hazard and mitigation plans. This provides for a more complete assessment of the hazard and mitigation plans, to ensure that mitigation plans are commensurate with the hazard.

A fourth step in the hazard analysis process is used for hazards with mitigations involving active controls. Here, control of a hazard or its impact relies on active monitoring or control to prevent the mishap from coming to pass. All such hazards are subject to control requirements defined in Ref. [11] LCA-139, "Camera Hardware Protection Plan." These hazards, their active controls, and verification plans are listed in Ref. [12] LCA-140, "Camera Hardware Protection Protocol List."

The system safety program is fully integrated with the rest of the PSA program and management of the project. This is done primarily through the review processes described in Ref. [6]. Hazards, their mitigation and controls, and verification test methods are reviewed as part of the overall subsystem design. Manufacturing and test readiness reviews add further emphasis to assembly and test procedures to assure that all mitigations and controls are in place and fully functioning.

9. ES&H Assurance

9.1. ES&H Program Plan

The LSST Camera project is committed to protecting the health and safety of all personnel involved with the project, the public, and the environment, through the life of the project. Each of the project's institutions participating in hardware development is responsible for assuring that Environment, Safety and Health programs consistent with this Plan are implemented for Camera work at their institution. In addition, management at all levels is expected to ensure that all personnel involved in Camera work understand the content and importance of these plans. In turn, employees are responsible for integrating ES&H considerations into their own work activities.

The Camera project has implemented three programs for assuring that personnel and system safety processes are incorporated into all aspects of the project. These are described below.

9.2. Institutional ES&H Programs

The Camera project involves development, fabrication, and testing work at collaborating institutions around the world. To ensure that all work performed in support of the Camera project is done in a safe manner that respects worker and collaborator health and the local environment, all institutions involved in Camera work are expected to develop an Institutional Safety Implementation Plan (ISIP). These Plans delineate the local, institutional ES&H plans that are invoked to govern all Camera work at the institution. These institutional plans define programs used locally as well as address specific safety issues regarding Camera work being performed at the institution. The institutional programs are managed by an institutional safety officer, but the ISIP is reviewed and approved by the Camera Safety Officer.

ISIP's also establish requirements for personnel involved with Camera work at the institution. In particular, they define the minimum training and other requirements for collaborators who may visit and work at the institution. This helps to clearly establish expectations for all who work on site, regardless of where they come from.

Minimal content for ISIP's include the following topics:

Institutional and agency requirements and implementation policy and goals

Roles and responsibility of institutional representative(s) and LSST Camera managers

Worker responsibilities for employees and non-employee collaborators/visitors

Processes for workplace hazard identification, assessment and control

Safety review process

Camera facilities and occupational hazards associated with them

Facility access and security, including computer and network security and facility monitoring and emergency response

Training

Injury and incident reporting process

Environmental protection processes

While ISIP's are Camera project documents, they are expected to refer to institutional standards, plans, and procedures for most of the topics they address.

9.3. Safety Assurance Processes

Three processes are used to assure that Camera and institutional ES&H and system safety procedures and considerations are part of Camera implementation plans: safety reviews, work planning and control processes, and auditing of ES&H program implementation.

9.3.1. Safety Reviews

The technical review process is the primary mechanism to manage the development effort and assure that system performance requirements and system and personnel safety are adequately factored into the design. This process and review deliverables are defined in Ref. [6], "Camera Design Review Plan." The review process defined in this plan includes external assessments of both system performance as well as system and personnel safety. All subsystem technical review committees include a safety representative to provide feedback and identify any possible deficiencies or actions needed in response to the review. These actions are tracked as part of the system engineering and development effort, to ensure that performance and safety issues that have been identified are resolved satisfactorily.

Safety-specific reviews are also described in Ref. [6]. Subject-matter-specific safety reviews may be held as part of the run-up to a subsystem's Final Design Review (FDR) or TRR. These reviews constitute one part of the ES&H program at SLAC and have been adopted by the LSST Camera to assure that subsystem designs and equipment that is delivered to SLAC meet or exceed DOE ES&H requirements. Thus, these form part of the ES&H assurance and review processes for all subsystems, regardless of the origin of the design and hardware. Safety Reviews are technical reviews addressing the personnel hazards associated with subsystem design, manufacture, assembly and test, and operation. They are intended to provide assurance that hazards have been sufficiently analyzed, that appropriate controls are planned to mitigate or eliminate the hazards, and that the activity conforms to SLAC ES&H policies.

9.3.2. Work Planning and Control

The third process for assuring that personnel and system safety are incorporated into Camera processes and procedures is through review of procedures and travelers as part of the Work Planning and Control (WP&C) process. Process, fabrication, assembly, and test hazards are all captured in the respective procedures and travelers that are used to delineate the process and collect data about how it was performed. These procedures are reviewed at MRR's and TRR's, prior to first use or first application of power. In all cases, the procedures and reviews include specific provisions for controlling any and all hazards associated with the process.

The Work Planning and Control process is further described in Section 16, below.

9.3.3. Auditing Processes

Local institutional ES&H implementation programs are also audited. Here, the local institution's ISIP defines local ES&H standards and officers. The institutional officers have the authority and responsibility to audit Camera work at their institution to assure that institutional requirements and

standards are being met. Furthermore, the CPM, Camera Safety Officer, and QA Manager all have the authority to call for an audit or full review of Camera implementation of institutional ES&H plans, working in conjunction with the institutional officers.

10. Quality Assurance

10.1. Quality Assurance Program Plan

The LSST Camera project is committed to controlling activities that affect product performance or the safety of personnel or camera hardware and equipment. Such activities are controlled at institutions participating in hardware development, consistent with the processes implemented by the Camera project and flowed down through Camera subsystems.

A number of processes are used to assure that Camera hardware products perform as required to meet project metrics. While more general quality assurance processes are described elsewhere in this document, five processes specific to hardware and components are detailed here. These apply both to subsystem development and manufacturing work, as well as to the processes and methods implemented by institutions in support of that work.

10.2. Institutional Quality Assurance Programs

To ensure that all work performed in support of the Camera project incorporates work processes to assure the quality of the resulting product, all institutions involved in Camera work are expected to develop an Institutional Quality Implementation Plan (IQIP). These Plans delineate the local quality assurance and process control plans that are invoked to govern all Camera work at the institution. These institutional plans define programs used locally as well as address quality issues regarding Camera work being performed at the institution. The institutional programs are managed by an institutional quality assurance manager, but the IQIP is reviewed and approved by the Camera QA Manager.

Depending on the hardware being developed, IQIP's may establish requirements for personnel involved with Camera work at the institution. In particular, they may establish training requirements for people involved with production and testing of Camera hardware, as well as requirements to use institutional systems as they support the Camera work.

Minimal content for IQIP's include the following topics:

Institutional QA roles and responsibilities: QA manager and organization; lines of authority within the institution and as related to Camera institutional lead and managers

Inventory control and parts storage: either institutional processes or camera-specific plans defining inventorying processes in response to this document

Suspect/Counterfeit Item prevention program: institutional plans, if any, or plans to use Camera or SLAC program

Work planning and control methodology: any institutionally-mandated method; any methods that vary from those described in this document

Procurement process standards: refer to institutional processes

Equipment calibration and control program: if any exist, and if it is used for managing calibration of equipment used for Camera work; otherwise, calibration is expected to be handled by Standard Operating Procedures (SOP's) for the specific facilities and equipment, and these should be referenced

Institution training and personnel database: refer to this if it is used for managing training records for Camera personnel; otherwise camera-specific SOP's should be referenced

Non-compliance and occurrence reporting program: if there are institutional mandates; otherwise, reference either the Camera program defined in this document or a local program

While IQIP's are Camera project documents, they are expected to largely refer to institutional standards, plans, and procedures for most of the topics they address. If institutional programs are not available, and those defined in this document are not adequate, then custom programs need to be referenced in the IQIP and submitted for approval by the QA Manager.

10.3. Critical Item Tracking

Critical items are defined as any part or component whose failure would have significant impact on the safety of the system or personnel, or on the ability of the system to perform within specification (either due to down-time or out-of-spec operations). All critical items associated with system or personnel hazards must be captured in Ref. [10], "Camera Hazard List," while other critical items are flagged by subsystems.

For mechanical components, critical items are ordered from most to least critical as follows:

Pressurized components
Lift/transport fixture
Single failure point
Primary structural element
Singly-redundant item
Secondary structural element
Multiply-redundant item

This is detailed in Ref. [13], "Camera Mechanical Standards," and supporting documents, along with the methods needed to address the development, manufacture, and use of critical mechanical components.

Critical electrical and electronic components are likewise ordered from most to least critical as described in Ref. [14], LCA-10098, "Camera Electronics Standards."

Whether electrical, electronic or mechanical, the use of critical components involves tracking the components through the development, fabrication, and operation of the component. Critical components are identified then tracked throughout their lifecycle by flagging them and applying special constraints in the following areas, as appropriate for their use:

Design and analysis: applying special design rules or factors of safety

Materials and part selection: procuring using certifications or other qualification or acceptance test processes

Fabrication and testing: clearly defining fabrication and test procedures and developing work process controls to assure that the finished product meets all requirements

Operations and maintenance planning: developing procedures for operating, inspecting, servicing, troubleshooting, and replacing parts during operation

10.4. Identification of Materials, Parts, and Components

All parts and component assemblies shall be uniquely identified in one of three ways. First, parts or components deemed suitably unique or complex will use a unique serial number to distinguish them from all others. These can be manufacturer serial numbers or numbers applied in-house. The recommended method for using serial numbers is by appending a three-digit number to the end of the drawing number (e.g.: LCA-12345-C-147, where "147" is the serial number, "C" is the revision letter of the drawing, and "12345" is the drawing number). Alternately, serial numbers can include a three- or four-letter prefix with a three- or more digit number.

Second, piece-parts, bulk parts, or materials of particular criticality can be identified by lot number or some other identifier distinguishing unique manufacturing runs or material information. Here, the parts or materials must be inventoried separately, and the part's lot number recorded at final application to provide traceability.

Third, bulk parts can be identified solely by manufacturer or project part number, signifying the drawing, processes, and materials with which the part was manufactured. Here, the expectation is that all parts procured or fabricated to that part number can be considered fully interchangeable with minimal risk.

The item may be stenciled, engraved, a placard attached, or otherwise encoded as appropriate to the circumstances.

10.5. Inventory Control

All parts, components, purchased components, and assemblies must be stored, and their use controlled. Typically, parts should be controlled using parts lists of next assemblies as the control methodology. Thus, piece parts and purchased items would be tracked based on their part number on the assembly where they are used.

In general, common parts should NOT be stored in parts bins or open inventories. Thus, purchased components (e.g.: M8 socket-head cap-screw) are procured and inventoried based on their final location of use. This avoids the significant risk of using the wrong type of part in an assembly (e.g.: using a stainless steel cap-screw where a high-strength carbon steel cap-screw is required).

10.6. Quality Assurance Board

The Camera Quality Assurance Board is responsible for approving the selection of materials, electrical, electronic, and electromechanical, and purely mechanical parts. The QA Board also reviews non-compliances and requests for waivers or use of non-complying parts or materials. The part and material review and approval process provides a means to assess and accept the proffered parts for use in a particular application in the camera. In general, the review process assesses acceptability in these areas:

Cleanliness/contamination: is the part tested and rated to be suitably clean for its use (particulates, outgassing, water retention)

Environmental conditions: is the part rated for the full range of environments it will experience

Reliability: failure rates and mean time between failure (MTBF); effect on subsystem entity uptime

Parts performance: ability to meet requirements; adherence to standards as applicable; check that parts are not on industry watch-list

The QA Board review process starts in the run-up to FDR where draft materials lists are submitted and reviewed/approved. This supports subsystem final design development, then continues to the MRR, where parts lists and procedures are finalized on assembly drawings that are ready to release. The QA Board approves these final parts list on the assembly drawings as part of the release process. After this, changes during production or subsequent revisions are handled by the QA Board as part of either a controlled revision process to drawings or procedures, or in support of dispositioning Non-Conformance Reports.

10.7. Suspect and Counterfeit Item Prevention Process

The Camera recognizes the importance of reducing the probability of the introduction of suspect/counterfeit items (S/CIs), increasing the likelihood that such items will be detected, and assuring that identified S/CI's—and the processes that introduced them—are addressed in a timely and deliberate fashion.

A suspect item is one in which there is an indication by visual inspection, testing, or other information that it may not conform to established government or industry-accepted specifications or national consensus standards. A counterfeit item is a suspect item that is a copy or substitute without legal right or authority to do so, or one whose material, performance, or characteristics are knowingly misrepresented by the vendor, supplier, distributor, or manufacturer. The use of suspect/counterfeit items can lead to unexpected failures, increased risk of performance impacts, environmental impacts, or personal injury.

Camera quality assurance processes described in this document serve to reduce the probability of using S/CI's, as well as to mitigate the impact of their accidental introduction in downstream work processes. In particular, three assurance processes provide a three-tiered line of defense in addressing S/CI's.

10.7.1. Procurement Procedures

As S/CI's are always introduced by a procurement, the procurement processes described in Section 13 provide the primary line of defense against the introduction of S/CI's. Processes include defining clear specifications for purchased hardware, using industry standard specifications when possible, and delineating acceptance criteria and tests to control the quality of the incoming hardware.

10.7.2. Process Controls

For S/CI's that are inadvertently received and accepted, clear work planning and control processes can help to identify them during downstream operations. Requirements for this are described in Section 16. Clearly defined work processes and in-process testing, as well as final acceptance testing serve to increase the chance of detecting S/CI at low levels of assembly where failure of a component has a more contained impact.

10.7.3. Non-Compliance Reporting

Section 18 describes processes associated with quality improvement practices. This includes identifying and dispositioning non-compliant parts and materials, as well as developing corrective action plans.

These processes are also vital in reporting and dispositioning discovered S/CI's. Here, non-compliances possibly linked to systemic or process-oriented issues—as introduction of S/CI's are—are assured to be escalated quickly and corrective actions taken over as wide a range as needed.

10.7.4. Oversight and Auditing

The Camera QA Manager and institutional QA Managers also provide important roles in overseeing assurance processes at all institutions. Independent of subsystem managers and personnel, they monitor the effectiveness of programs at all institutions involved in Camera work, as well as providing information to local personnel as needed by disseminating accurate, up-to-date information on S/CIs and associated suppliers using all available sources. S/CI information sources include the following:

Government-Industry Data Exchange Program (www.gidep.org)

Institute of Nuclear Power Operations (www.inpo.org)

DOE Occurrence Reporting and Processing System (http://www.eh.doe.gov/paa/orps.html)

DOE S/CI Web site (http://www.eh.doe.gov/sci/)

11. Standards

Standard methods and processes are used throughout the camera to assure uniformity of outcome and higher probability of Camera performance and safety requirements being met in the final product. Standards documents are used for establishing standard methods in two areas. First, design standards are implemented to ensure the development of a unified, coherent, self-consistent, and standardized set of analyses, drawings, procedures, and manuals. Second, process standards provide criteria for assuring that fabrication, assembly, and test processes used in the manufacture of camera components meet minimum acceptable criteria. These types of standards are discussed below.

11.1. Design Standards

Design standards are used as part of the process to assure that performance and safety requirements are met. Standards and plans invoke uniform methods to be used in all aspects of camera, subsystem, and component design and development. The following plans and standards invoke standardized design practices on camera systems:

[13] LCA-280, Camera Mechanical Standards: standardized practices for analysis; uniform drawing and manufacturing methods; camera coordinate, numbering, and configuration conventions; policy on metric

[14] LCA-10098, Camera Electronics Standards: identifies industry standards for design of circuit boards and electronic component selection

[15] LCA-10099, Camera Software Standards

[16] LCA-279, Contamination Control Plan: establishes standardized design practices and materials testing and approval methods for components

[17] LCA-278, Grounding and Shielding Plan: defines ground paths within the camera and standard grounding and shielding methods to be used

[11] LCA-139, Hardware Protection Plan: defines standardized requirements for local protection system elements and controllers

11.2. Process Standards

Process standards are used to govern the development and implementation of procedures and processes for assembly, test, and operation of camera components and assemblies. As part of the manufacturing and test review process described in Ref. [6], procedures are reviewed to assure that they comply the appropriate process standards.

The following plans and standards establish standardized processes to be used during assembly, test, and operation of all camera systems:

[16] LCA-279, Contamination Control Plan: defines minimum cleanliness standards and protocols for handling, storing, and using parts and assemblies to meet cleanliness requirements.

[17] LCA-278, Grounding and Shielding Plan: defines standard grounding methods to be used and test processes to assure that systems are adequately grounded

[18] LCA-10032, Electro-Static Discharge (ESD) Control Plan: defines standard processes and precautions to use in handling, storing, and testing ESD sensitive components and assemblies

12. Reliability Assessment

Reliable operations of Camera parts, components, and assemblies is critical in assuring that the camera meets performance and uptime requirements while self-protecting against hazards that may damage the camera. Design standards, part selection, and test planning all factor into component and system reliability, and are addressed in Ref. [13] and [14].

These describe critical item lists and tracking of design, fabrication, testing, and use of parts that affect overall reliability, requirements for electrical, electronic, and electro-mechanical (EEE) and mechanical parts stress analysis, and worst-case and failed-state analyses.

13. Procurement

13.1. Introduction

Procurements from vendors under a purchase order or subcontract are accomplished in accordance with institutional procurement policies. Procurement planning is an essential and integral part of the procurement process and includes determination of the anticipated QA requirements and quality control (QC) activities for a particular procurement. The following sections define issues to consider in developing plans for all procurements.

13.2. Selection and Evaluation of Vendors

Potential suppliers of critical, complex, or costly items or services shall, prior to the award of a contract, be evaluated in accordance with predetermined criteria, to ascertain that they have the capability to provide items or services that consistently conform with the technical and quality requirements of the procurement. The determination of which suppliers shall be evaluated will be made by project technical personnel, in conjunction with the QA Manager and the institutional buyer or contracts specialist.

The evaluation may be based upon the results of one, or a combination of, the following methods:

Review of the supplier's quality history with the institution or collaborators
Survey or evaluation of the adequacy of the supplier's quality system
Review of the supplier's quality history in providing the same or similar items or services

Note that this evaluation is distinct from any assessment process to ensure that vendors are capable of performing the work. The quality management system evaluation and technical capability assessment may be done independent of, or in conjunction with, each other. They can be performed as part of a pre-qualification process before requests for proposals are issued, or in conjunction with evaluating proposal responses prior to selecting a contractor and finalizing a contract.

An evaluation report should be written, explaining the criteria used in the evaluation process and findings of the process.

13.3. Procurement Documents

All design and specification documents that are used for describing the product or services to be procured are required to be configuration-controlled documents, and must be approved, released, and revised according to Ref. [20], "LSST Camera Configuration Management Plan." All such documents shall be reviewed and approved by the appropriate Camera subsystem managers and project office personnel as defined in Ref. [20]. Revisions to these documents shall also be reviewed and approved by the same organizationally responsible persons that approved the original documents. The institution's procurement office has the responsibility to ensure that the contents of the procurement documents are accurately and correctly transferred to the relevant contract or purchase order.

The Camera subsystem manager is responsible for ensuring that procurement documents fully describe the scope of the procurement. The scope of a procurement depends on the type of procurement, the criticality of the items being procured, and the complexity of the work involved. Managers should consider the following topics in developing procurement documents:

Specifications: documents or drawings completely defining the requirements for completion of the product being procured. These may also fully define the requirements for evaluation and approval of the delivered product.

Acceptance criteria: a definition of the requirements to be met for approval of all deliverables. This may simply be that all specifications are met, or may include delineation of a prescribed set of tests or inspections to demonstrate functionality. This also includes acceptance criteria for approval of contractor procedures and processes.

Statement of work: a description of the work required to be performed by the contractor. For service contracts, this fully defines the work to be performed. For product contracts, this may define required in-process steps and deliveries such as development of manufacturing plans, test plans, drawings, or other manufacturing documents. This may also define required reporting intervals, as well as requirements and timelines for Camera and institutional approval of contractor plans and procedures.

Requirements on quality management system: requirements that a contractor must meet in the processes they use in execution of the contract. This may include requirements on contractor work planning and control processes, inventory and parts tracking methods, training and minimum personnel qualification, in-process testing, and any other quality assurance processes.

The requirements associated with these topics need to be specified for a given procurement based on considerations of safety, programmatic importance, technical criticality, complexity and intended application of the item or service. In particular, procurements associated with single-failure point items, pressurized components, lifting equipment, and materials and mechanical and electrical parts called out in other parts of this document may involve specific requirements. See the appropriate sections in this document for further details.

13.4. Surveillance, Testing and Inspection

Three types of inspection programs may be required for a procurement, depending on the complexity and duration of the procurement, number of parts being procured, and technical or programmatic criticality of the procurement to the Camera project. These are described below, with minimum requirements and considerations for each type.

13.4.1. Source Surveillance

The contracting institution and, by extension, Camera personnel, must reserve the right to survey contractor facilities and review contract progress at any time during the course of the contract. For extended contracts or complex procurements, specific surveillance activities should be explicitly called out in procurement documents. These should be used as gateways or release points to authorize the start of a new phase of the procurement. Surveillances should be performed at intervals consistent with the importance and complexity of the item or service. Upon acceptance of the item during source surveillance, documented evidence of acceptance of source verification should be furnished to the QA Manager, the procurement office, and the contractor. Note that acceptance of an item during source surveillance does not relieve the vendor of its quality responsibilities.

13.4.2. In-Process Testing

Requirements for in-process testing and inspection should be defined in procurement documents, and contractors should clearly define the nature of the tests, test equipment, and evaluation criteria for all such tests. The goal of these tests is to assure that process steps and controls are producing acceptable outcomes. Thus, test reports should clearly define what those outcomes are and how they are evaluated. Test plans should also include any sampling plans and the rationale for the sample size and sampling methods to be used.

13.4.3. Receiving Inspection

Camera subsystem and institutional leads must inspect and test all products received in fulfillment of a contract. This inspection process must include testing of the product, as well as review of any test or manufacturing records delivered with it. See Section 14 for further information about inspection processes. Purchased items shall be inspected as necessary to verify conformance to the specified requirements, taking into account source surveillances and audit activities and the demonstrated quality performance of the supplier.

13.5. Certificates of Conformance

When certificates of conformance are required from vendors, the requirement is specified in the procurement documents. Furthermore, mill certificates of chemical and physical analysis may be required for raw materials and fasteners, depending on their application. Certificates of conformance may be requested from vendors producing items to project specifications or drawings when other quality verification methods are not employed.

13.6. Non-Conformances

Contractors and Camera personnel are responsible for identifying non-conforming work or delivered products. Any completed work or items not meeting the drawings, specifications and contract requirements are to be deemed non-conforming.

Any non-conformance in the delivered product or service is to be submitted to the procurement manager. The nonconformance submittal must detail the area of the problem, and cite from the drawings, specifications or other procurement documents, how or why the work does not conform. Camera subsystem and institutional leads are responsible for determining the preferred course of action. This may include rejecting and returning the part, re-working the part such that it meets all specifications, or accepting the non-conforming product as-is. See Section 18, below, for further details and requirements for dispositioning non-conforming products.

14. Inspection and Testing

14.1. Test Planning

14.1.1. Types of Inspections and Tests

Inspections, measurements, and tests must be performed throughout the process of fabricating, assembling, and operating parts, components, sub-assemblies, and full assemblies of Camera subsystems. Such tests perform vital functions both in verifying that components meet their requirements and specifications, as well as in monitoring and assessing the work processes being used.

While tests may vary in scope and complexity, they fall into one of these general categories:

Receiving inspection: inspection or test at receipt of a component from a sub-contractor; this is performed to verify that the contract has been fulfilled at that the requirements of the contract have been met. See Section 13.4.3 for information on this.

Component inspection or testing: measurement, inspection, or functional testing of discrete components; these often may be simple pass/fail tests where failed components are discarded, and are often precursor tests before components are used in higher levels of assembly

In-process testing: tests to assure that process steps and controls are producing acceptable outcomes

Verification testing: tests to demonstrate that all functional and performance requirements of an assembly are met

Acceptance testing: an abbreviated version of verification tests to demonstrate full functionality at delivery, often of a subsystem sub-assembly

14.1.2. Test Procedures

Test procedures are required for all types of testing and inspections. Since inspection and testing are intended to demonstrate compliance with preset requirements or expectations, these requirements must be clearly delineated in the test procedure. In particular, test procedures must include the following content:

Characteristics being tested: requirements and functionality being tested

Pass/fail criteria: clear delineation of criteria to establish if a component passed the test or inspection; this should include, where needed, a description of how the comparison is made and any analysis of test data that is needed to make this assessment

Test equipment: equipment to be used in executing the test; this should include any special set ups of the equipment

Test process: step-by-step procedures (a.k.a.: work instructions) to be followed in the execution of the test; this is intended to assure that the test is repeatable and produces consistent results

Expected test data: data to be collected as part of the test process

14.2. Test Control

Since tests are vital to assuring that requirements and functionality of Camera systems are being met, the testing process must be controlled. The following topics must be addressed either in the test procedures or log books to ensure that test conditions and outcomes are subject to controlled and understood processes:

Pre-conditions: entry criteria that must be satisfied before a test is undertaken; this could involve criteria for the hardware being tested (e.g.: state of assembly) or criteria of the test set-up itself (e.g.: level of temperature stability of the equipment)

Test procedures: step-by-step instructions for executing the test

Test being performed: including revision of test scripts and procedures that are used

Test conductor: list of allowed test conductors or criteria to be a test conductor; personnel conducting a test should be recorded

Test date and time: especially if this is used for cross-referencing against equipment calibration status

Test equipment: equipment used for the test; include serial or test station number if more than one station is used for a given test; equipment calibration status may be recorded or separate calibration records can be referenced using the test date as the reference point

Exit criteria: criteria for evaluating whether a test article passed or failed a particular test; this should include directions for the disposition of the equipment

14.3. Control of Test and Measurement Equipment

Test, monitoring, inspection, and measurement equipment must be controlled to assure that they produce consistent results. Control processes should include the following:

Equipment identification: test equipment must be uniquely identified by serial number or other methods; this is especially important when there are multiple test stations; identification should include calibration status

Calibration program: test equipment should have a program for calibration and periodic re-check; calibration records should be maintained for reference, and calibration should be against industry standards, when possible, or pre-establish standards for custom equipment

Log book: log books either for individual test pieces or for the facility should be used to track calibration status of equipment. Records shall be established and maintained to indicate calibration status and the capability of measuring and test equipment to satisfactorily perform its intended function.

Calibration and control measures are not required for commercial equipment when such equipment can provide the required accuracy without calibration.

14.4. Test Outcome

14.4.1. Approval

Test results and test data must be reviewed and evaluated by the cognizant manager, engineer, or scientist to determine if the test was passed. Specific approval signifying that a test was passed is required to clarify the status of the tested component. This helps distinguish between a test just being completed and a test being passed or failed.

In general, test approval for in-process and component testing may not require engineer or scientist approval, but approval authority should be clearly established in the test procedure. Since these tests are often low-risk tests, it may be sufficient that the test operator approve the test, and simply report completion of the test.

14.4.2. Dispositioning of Tested Components

Components that have completed a test procedure fall into one of the three categories below:

Passing: components that have successfully passed a test and meet all criteria; test results have been approved as required in the test procedure

Non-conforming: components that have not met the criteria for passing the test; this could be due to non-performance of the component itself, or because of problems or irregularities of the test equipment; in either case, the component is considered non-conforming, and an NCR process is initiated per Section 18.3

Embargoed: components that have anomalous test results; this requires further clarification before a determination is made, but does not automatically mean that the component is non-conforming.

Note that if test equipment is found not to meet calibration requirements, then the validity of prior test results must be called into question. Components must be embargoed if they had been tested earlier using equipment that has been determined to be out of calibration.

The disposition of tested components should be clearly identified both on the component itself and in the test procedure documentation.

14.4.3. Test Records

Inspection reports, test results, and testing travelers are all quality records in that they demonstrate compliance of a component to established requirements. As records, they must be controlled pursuant to and Ref [20], the “Camera Configuration Management Plan.” The test planning process must clearly establish the expected test records to be collected.

Test data files and meta-data must also be managed and stored in such a way to allow for the reconstruction of the test conditions and equipment. Test data must be referenced both to the component being tested and the test equipment. This typically requires that test data files include references to component serial numbers and either equipment serial numbers or test station numbers. Test date and time must also be included to be able to cross-reference the test results back to calibration status of the test equipment

15. Software Quality Assurance

Ref. [15], the "Camera Software Standards" defines the quality management system for camera software. This includes definition of software code management processes, code release and documentation, and code revision control processes.

16. Work Planning and Control

16.1. Work Planning and Control Requirements

Work performed on the Camera project is regarded in terms of work processes or procedures. Each work process consists of a series of actions planned and carried out by qualified workers using pre-specified work processes and equipment under administrative, technical, and ES&H controls to achieve an end result. For a particular subsystem and institution within the project, these work processes are defined in response to three sets of requirements or constraints.

First, work processes are required to clearly define the work to be performed to meet well-understood end conditions. For most fabrication, assembly, and test processes, the work described in the work process or procedure should address all of the following topics. They must be clearly identified and conveyed to workers in every work process description, prior to beginning work.

Scope of work: description of the work to be completed

Infrastructure: facilities and workspace to perform the work, process equipment to be used, supporting services, and work environment (noise, temperature, humidity, lighting)

Qualifications: minimum training and any other qualifications for the people performing the work

Workmanship standards: standards to be used in completion of the work, including any standard operating procedures for the facility

Hazards: analysis of hazards associated with the work, either to personnel or hardware; the goal of this process is to ensure that the hazards associated with work activities and facility operations are clearly understood and appropriately controlled

Controls: controls and mitigation to reduce the hazards to acceptable levels; this should include a description of the means to verify that controls are in place

Requirements: definition of acceptance criteria applicable to the work and final product; this may be in drawings, or pass/fail criteria for a test

Work instruction steps: step-by-step list of work to be performed, suitable for minimally-qualified personnel to complete the work with the training defined above; this may include drawings, photos, or other graphical information

Second, work processes must be responsive to institutional environment, safety, and health requirements, as defined in their ISIP. These may levy specific requirements on work processes involving personnel safety, industrial hygiene, environmental conditions, or equipment safety. They may be required to meet institutional regulatory or contract requirements using approved instructions or procedures.

Third, procedures should define processes consistent with industry best practice and technical standards whenever possible. If not, or for non-standard processes, procedures should be validated on first-article test hardware to ensure they are appropriate. See Section 16.4 for further details.

16.2. Work Process Controls

All work must be planned, authorized, and released before work is initiated. This means that procedures and work processes are written and reviewed prior to the work being performed. Procedures must be approved by Camera subsystem managers and the Camera QA Manager, as well as institutional ES&H and QA officers. The approval process may also require more in-depth review of the procedure by subject-matter experts prior to approval.

Procedures must always be under revision control. Thus, only approved procedures should be used for Camera work. Changes and revisions to the procedure are acceptable, but should be incorporated into an updated revision of the procedure that is then reviewed and approved. Deviation from the originally-approved work process should be captured in red-line change-notices per processes defined in Ref. [20], and may require the use of a non-compliance report.

According to the local ISIP, the institutional safety officer must monitor the safety performance of workers in performing approved work processes, and provide prompt and useful feedback to influence safe behavior and continuous improvement.

16.3. Types of Work Processes

Approved procedures are required for manufacturing, test, handling, and operation of Camera components and assemblies. These come in many forms, but are categorized by the following types:

Manufacturing processes: steps in fabrication or assembly of parts, components, or assemblies

Test processes: procedures used for running tests as part of an acceptance process; these are fully described in Section 14, above.

Handling and storage procedures: steps describing safe handling of a component, preparation for storage, and storage conditions

Transport procedures: process describing preparation for transport, and procedures to monitor the shipping process and recover from shipping at the destination

Standard operating procedures: procedures defining standard operations of a piece of equipment, protocols for use of a facility or room, or recurring operations

Operating and maintenance procedures: work processes describing the operation or maintenance of an assembly

16.4. Process Validation

Whenever possible, work processes should be validated prior to use for on-telescope hardware, especially high-value, sensitive, or long-lead equipment. The validation process may include

demonstrating the safe and successful completion of the procedure using pathfinders, dummies, or engineering test unit hardware. The validation process should address the following issues:

Qualification of the design: if other tests are not performed to separately qualify the design to meet its requirements, the procedure validation process may address this

Approval of equipment: acceptance of the equipment used and methods of use; this may include confirmation of the calibration plans and acceptable ranges for the equipment

Qualification of personnel: confirmation of the training processes as well as validation that the work process is repeatable for all possible personnel

Validation of process steps and methods: demonstration that the discrete steps and methods described in the procedure produce acceptable results.

17. Training

17.1. Training and Job Proficiency

Training and evaluation is an essential part of the assurance program, and provides the foundation of competence needed to successfully carry out the procedures developed in the work planning and control processes described in Section 16. Training requirements for personnel working on Camera components or in Camera-managed facilities are set on an individual basis. For employees, Camera supervisors or managers are responsible to make a determination of qualifications and skills required for an assignment, and to identify the training needed. For Camera personnel working at collaborating institutions, and for sub-contractors working on site, the institutional point-of-contact is responsible for defining the training needed. In all cases, training needs to be commensurate with the scope of work to be performed by the individual, complexity of the job function, and exposure to hazards while on the job.

Training programs must include the following:

Job hazards and controls: specific training to address exposure to personnel hazards and on-the-job safety; this must also address all locally-required ES&H training for personnel to comply with institutional ES&H programs, as referenced in the institution's ISIP.

Awareness of responsibilities: introduction to the relevance and importance of worker activities and how they contribute to the achievement of Camera quality objectives and Camera and institutional ES&H policies.

System safety awareness: training addressing the sensitivities of the Camera hardware and equipment that personnel will be working with. This may include training to address contamination control processes, electro-static discharge control procedures, and any sensitivities or equipment hazards associated with the specific work at hand.

Specific skill development: training to teach and assess skills particular to the work to be performed. This may include training to certify personnel for general work such as rigging or crane operation, or for specific tasks to be performed.

For all training, courses must be taught by qualified instructors and include an evaluation process to ensure that the personnel have been suitably trained. This evaluation process should also include a process to evaluate the effectiveness of the training courses in educating personnel.

17.2. Training Status Monitoring

Institutional Safety Implementation Plans describe the method by which local safety training status is monitored. This includes training requirements based on the identified hazards, required courses and frequency of re-training, status and completion dates for all required training, and a method to flag when training periods expire and re-training is required. These systems may use institutional training databases or a custom system for Camera project work. Furthermore, the institutional database or a Camera-specific training log also tracks all job skills training classes.

18. Quality Improvement

18.1. Introduction

One of the primary goals of the performance and safety assurance program for the LSST camera is the prevention of conditions and situations that jeopardize the successful accomplishment of the project and completion and verification of the camera and its ancillary hardware and software. The assurance program described in this document is intended to reduce the likelihood and risk associated with occurrences that result in personnel injury, harm to the environment, loss of performance, excess costs, or schedule delays.

The following sections describe the method by which any such incipient occurrence is prevented, then identified and reported if it does come to pass. Processes are described for segregating or quarantining non-conforming items, then for establishing root causes for the occurrence and plans for taking corrective action. Finally, project quality improvement methods are described.

18.2. Preventive Action

The processes described in this Plan are intended to assure the quality of the final product and that the processes used are adequate to meet prescribed camera requirements. However, they also provide the first—and most fundamental—level of insurance in preventing occurrences from occurring. Properly applied, the safety and design standards, work processes, ES&H processes, procurement, inspection and testing methodology, and training plans, are intended to reduce the probability of occurrences from happening. This is the case since occurrences are, by definition, anything that happens that is out of the scope of behavior expected and established by the appropriate processes, standards, and controls.

However, during the execution of the project, four specific activities are continuously performed with the goal of preventing occurrences. These are described in the sub-sections below.

18.2.1. Review of Work Processes

Fundamentally, the work planning and control methodology described in Section 16 serves as the foundation of the performance and safety assurance process. Thus, initial and on-going review of the work processes that are used is paramount in assuring that the processes are fulfilling their needed function. This is the first and foundational step in the occurrence prevention process.

18.2.2. Work Process Auditing

During fabrication, assembly, integration, and test, work processes are audited as a further prevention method. Here, auditing addresses three areas of potential deficiency. First, work processes may not be adequately describing the processes that are actually being performed. Incomplete, vague, or incorrect information is being conveyed or the actual processes being used have been developed in some ad hoc way. In either case, the work process needs to be reviewed and revised. Second, work processes are audited to check that workers are complying with them. This is especially important for processes involving safety and health. Finally, processes are audited to track the outcome and how well—or poorly—the final product is meeting its requirements. This can provide insight into the quality of the processes and whether they need to be changed to improve the outcome to better match intentions.

18.2.3. Trend Analysis

For processes detailing repetitive work or multiple parts, further review of the outcome may be warranted to look for trends suggesting a gradual reduction in the quality of execution of the processes or in their intended effect. Such trend analysis may involve investigating trends in the process itself, such as the time required to accomplish a certain set of steps, or the time/temperature profiles of a burn-in cycle. Trend analysis may also be used to directly assess the end products and how well they meet their end requirements, to look for correlations between changes in final performance to small changes to process steps.

This analysis, in particular, may identify incipient failures or patterns that will ultimately produce non-compliant products or unsafe situations, if left un-changed. Such insight can then be used to review and revise work process steps to address the patterns.

18.2.4. Corrective Action Planning for Lesser Occurrences

The final method to prevent occurrences is actually to assure that corrective action planning and execution for prior, lesser occurrences is carried out successfully. In retrospect, significant occurrences regarding safety and underperformance can often be traced back to relatively innocuous predecessor events that, if dealt with adequately, would not have escalated. Thus, review of corrective action plans and their implementation is an important preventative action. Often, this process takes place at the project level to assure that subsystem process controls are in place and being effectively managed.

18.3. Occurrence Reporting

As described above, occurrences are, by definition, anything that happens that is out of the scope of behavior expected and established by the appropriate processes, standards, and controls. These can vary in scope, severity of impact, and effect on the program, but three classes of occurrence are defined to reflect the responsibilities of the local institution:

Affects personnel safety or the local environment: for all such occurrences, reporting is handled according to local institutional protocols and structures, as defined in the ISIP (as delineated in Section 9.2).

Affects sub-contracts or purchased products: non-conformances of procured products or services must be reported and addressed using local institutional methods, since they potentially involve local legal and contractual obligations (described in Section 10.2).

All other occurrences: any other occurrences affecting camera hardware, processes, or personnel; these are addressed using the process described below

The term "occurrence" is generic, describing many possible results including non-conformance, non-compliance, out-of-spec condition, problem, or test failure.

In all such cases, a Non-Compliance Report (NCR) or Problem/Failure Report (PFR) must be initiated to identify the occurrence, the hardware and test set-up involved, and other aspects of the context of the occurrence.

18.4. Segregation of Nonconforming Items

Items that do not meet requirements must be segregated, marked as "embargoed" and placed into a designated holding area until their proper disposition can be determined. When segregation is not possible or impractical, other precautions are to be taken to preclude inadvertent use or start-up of such equipment, including locking-out and tagging, or visibly marking the equipment.

At a minimum, nonconforming items or those that failed a test need to be identified as such, preferably with the number of the NCR or PFR that was initiated. Work processes that were in use at the time of the occurrence must be suspended and a note added that points to the NCR or PFR.

At no time should the nonconforming part be entered back into the fabrication or test process before review and initial disposition of the Quality Assurance Board. Continuing work that is otherwise not related to the occurrence may well be justified, but need initial review and acceptance by the QA Board.

Note that nonconforming parts or components involved in an occurrence or test failure must be embargoed or segregated, but ultimately can be dispositioned as acceptable for use and re-entered into the production stream. This is part of the corrective action process, and must only be done after approval of the corrective action and re-verification.

18.5. Corrective Action

After an occurrence has been reported by way of initiation of an NCR or PFR and segregation of nonconforming items, a corrective action plan is developed to address the root cause of the occurrence, modify work processes that led to the occurrence, disposition any nonconforming parts, and return to standard operations with revised processes in place. The primary responsibility for executing this corrective action rests with the group responsible for performing the work processes or producing the item in question. The cognizant manager is responsible for seeing that all appropriate corrective actions are adequate and taken in a timely manner. If the cognizant manager or QA Manager believes that a correction is not adequate or timely; the problem will be documented and brought to the attention of the Project Manager for resolution.

The corrective action process involves six steps that are detailed below. These are carried out by person(s) appointed by the cognizant manager, and approved and closed out by the QA Board. The NCR or PFR provides the focal point for documenting the information associated with these steps. Ultimately, the closed-out NCR/PFR forms the record of action taken, including any links to change notices associated with document revisions.

18.5.1. Review Occurrence Details

As soon as possible after the occurrence, identify the full extent of non-conformities or test failures. This includes characterizing the full range of non-conformities for the item(s) in question, but also investigating if similar or preceding items or tests suffered—or nearly so—a similar fate.

18.5.2. Determine Root Causes

Establish the cause for the non-conformity, failure, or occurrence. This includes identifying components, work processes, or tests that may also require review if subject to the same or similar root cause(s). The root causes may lie with the particular operation that caused the occurrence, but could also lie with pre-existing issues or design deficiencies that had here-to-fore not been exposed.

For test and manufacturing process failures, this step is important to avoid simply putting a band-aid on the proximate cause of the occurrence. Root causes could lie in other work processes, design problems or incompatibilities, or in materials or part deficiencies. Thus, these root causes could end up affecting other items beyond just those at hand.

18.5.3. Develop an Action Plan

Evaluate the need for action and define the steps both to address the root causes of the occurrence to prevent recurrence, and for remedial work to recover from the occurrence. This includes determining the appropriateness of granting waivers for using parts as-is. When nonconforming items are corrected, the action plan must include steps needed to re-verify the item, to demonstrate conformity to the requirements.

The action plan could include the following actions items, as appropriate:

Work process changes—modifications needed to processes to prevent recurrence
Design changes—revisions to design details, materials, part/material specifications
Re-training—modification of personnel training to address any deficiencies
Accounting of all items affected—listing of parts and serial numbers of all affected items
Remedial work process plans—steps required to recover from the occurrence
Re-verification plans—inspection and test processes required to re-verify affected items

Lessons learned should also be specifically listed. These tend to be more generic or qualitative lessons that can be applied to other situations, so it is important to identify those lessons and disseminate them throughout the project

18.5.4. Record Results of Action Taken

Complete any revisions and approvals of procedures, processes, drawings, and other documents. Record the revision approval in the NCR/PFR as evidence of the action taken. This provides a record of the close-out of the action plan and a return to standard operations.

18.5.5. Disposition Non-Conforming Items

Review and approve or reject any waivers and re-verification work, authorizing the final disposition of affected parts. This could result in items being used as-is, used with re-work/re-test, or scrapped. This is the last step of the NCR/PFR close-out process, so its completion marks the closing of the NCR/PFR. Final review and approval is then completed by the QA Manager as an assurance measure.

18.5.6. Review Effectiveness

Check that the action plan adequately addressed the root causes of the occurrence. This step is performed by the cognizant manager with the QA Manager, to ensure that as standard operations resume, there are no lingering issues associated with the occurrence and that the action plan appeared to effectively address the root causes.

18.6. Quality Improvement

Improvement teams may be appointed by the Project Manager to work on resolving significant problems or on improving operations. These teams may be composed of persons from several groups. They may address either general process problems (e.g.: procurement process delays, or lack of coordination of design activities), or specific issues related to a particular hardware element, process, or occurrence. These groups will be led by a facilitator appointed by the Project Manager.