LARGE SYNOPTIC SURVEY TELESCOPE

Large Synoptic Survey Telescope (LSST)

Project Execution Plan

Victor Krabbendam

LPM-54

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Signature Page

This Project Execution Plan is approved by:

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The LSST Project Execution Plan

1 Introduction and Overview

The LSST Project Execution Plan (PEP) describes the performance Baseline, long-term vision and the near-term policies and procedures guiding the Large Synoptic Survey Telescope (LSST) project through design & development, construction, and operations. The PEP describes how the LSST project will meet Federal and non-Federal Sponsor expectations for the construction of a large facility; provide maximum transparency into the levels and types of effort required to meet the project's goals; and inform and hold accountable LSST team members throughout the project's various work elements.

The PEP summarizes the LSST organizational structure, scope, management policy, and execution process through brief descriptions. Extensive references provide additional detail. The PEP content follows the guidance of the NSF Large Facilities Construction Manual, Appendix 3 (NSF, 2013c). Appendix A of the PEP cross-references the NSF guidance topics with PEP sections and other LSST documentation. The PEP and the referenced documentation establish the methods, systems, and strategies that will be implemented in order to execute the LSST project.

1.1 Overview

LSST has been conceived as a public facility. The image archive that it will produce, and the associated object catalogs that are generated from that data, will be made available with no proprietary period to the U.S. and Chilean scientific communities and other authorized communities as established through separate agreements. The LSST data management system will provide user-friendly tools to access this database and to support user-initiated queries run on LSST computers at the data access centers. We expect that the majority of LSST discoveries will come from research astronomers with no formal affiliation to the project, from students, and from interested amateurs, intrigued by the access to the Universe that this facility uniquely provides.

At the end of construction, the LSST project will deliver an 8.4-m telescope and all required support facilities on Cerro Pachón; a 3.2-gigapixel camera; a supercomputing and data storage facility in La Serena, Chile, along with offices for Chile-based staff; a major archive center at the National Center for Supercomputing Applications (NCSA) at the University of Illinois in Urbana-Champaign; and an LSST Headquarters facility in Tucson, Arizona.

The LSST project will then conduct a survey for 10 years, and will deliver to the community raw and calibrated data along with annual catalogs with reduced data for observed sources. Data Access Centers in La Serena and Urbana-Champaign will serve the data to the scientific community and will provide computing resources for data analysis. The headquarters will remain in Tucson, Arizona during the 10-year operation phase of the survey.

LSST is being pursued as a public-private partnership with the National Science Foundation (NSF) as the lead US Federal Agency. The NSF and the Department of Energy (DOE) have signed an interagency Memorandum of Understanding (Document-13847) to define their obligations as co-sponsors of the LSST Project. The NSF is the lead agency for the project and is responsible for developing and delivering the telescope and associated support facilities as well as the entire data management system. NSF funds for the LSST will flow through Cooperative Agreements with the Association of Universities for Research in Astronomy (AURA). These agreements establish the LSST Project Office as an AURA-managed center for the construction phase of the LSST project.

The DOE is responsible for delivering the camera system. The DOE has identified SLAC National Accelerator Laboratory (SLAC) as the lead organization for this portion of the project. SLAC manages a collaboration of other DOE national laboratories and high-energy physics groups at universities who support the Camera development, fabrication, and delivery. Funds for the camera flow directly from DOE to SLAC and fiscal responsibility for the DOE funds resides at SLAC.

The LSST Corporation (LSSTC), established in order to carry out the LSST Project, now serves as the agent for non-Federal funding contributed to the Project. LSSTC was instrumental in the early development of the Project and has raised more than $50M, applying it to early long-lead construction items and additional development efforts. LSSTC currently retains title to two key elements of the telescope--the primary/tertiary mirror (M1/M3) and the secondary mirror blank (M2)--but has signed a Memorandum of Understanding with AURA (Document-11647) to make these elements available for the telescope construction. In the future, LSSTC will use its resources to help prepare the community for science with LSST and will enter into agreements with international partners to secure additional financial support for operations.

A single LSST Project Office has been established to directly manage the design, development, construction, commissioning, and operation of the full LSST System. A single LSST Director, employed by both AURA and SLAC, is responsible to both Federal agencies and to the LSSTC. A single Project Manager is directly responsible for managing the integrated LSST Project, for managing NSF and non-Federal funds, and for administering the LSST Project Office. The LSST Project has established a central systems engineering team to ensure that all the subsystem elements will come together as a single integrated system meeting all LSST science objectives. MOU's and several contracts are in place to define the organizational responsibilities and authorities necessary to join the LSST Project as a single collaborative effort.

Processes and tools are in place to execute the fully integrated project as well as the individual elements. The LSST Project Office maintains the integrated project schedule, assembling and managing the complex interactions of the project including those funded directly by the different agencies. The Project office otherwise focuses on the responsibilities to NSF and LSSTC, leaving the detailed management of the LSST Camera Project to SLAC.

1.2 Background

LSSTC is a not-for-profit 501(c)3 Arizona corporation with headquarters in Tucson, Arizona. Incorporated in 2003, it was formed solely to design, construct, and operate the Large Synoptic Survey Telescope (LSST). Its mission statement reads: "To advance research and education by constructing and operating an observatory housing an astronomical telescope to be known as the Large Synoptic Survey Telescope (LSST)".

Since its founding, the number of LSSTC member institutions has grown from four to 36 at the beginning of 2013. Membership requires substantial contributions, either financial or intellectual, to the project; current dues are set at an annual payment of $25,000 to support LSST operations. At least five member organizations have made multi-million dollar cash and/or in-kind contributions. The criteria and process for accepting new members into the LSSTC are described in the "LSSTC Institutional Membership Application Policy" (LSSTC-13).

In October 2011, the LSSTC Board completed an agreement (Document-11647) with AURA that established the LSST Project Office as an AURA-managed center for the construction phase of the LSST project. The appointment of the LSST Director, who has a joint affiliation with AURA and SLAC, became official in July 2013, formalizing a single Project Director with formal authority and responsibility to both Federal Funding Agencies. Action by the LSSTC Board in April 2013 (Document-14670) gave the same LSST Director formal authority over LSSTC non-federal funding, thereby establishing a single point of contact for all LSST Project Sponsors.

The LSSTC submitted an MREFC construction proposal to the NSF in January, 2011; a revised version with AURA as managing organization was submitted in October 2011 (Document-10548). A successful Preliminary Design Review (PDR) was completed the week of August 29, 2011 in Tucson, Arizona. After the completion of the PDR, the project was asked to provide an integrated schedule and budget that matched the DOE funding profile. The revised MREFC budget and Integrated Project Schedule was reviewed in May 2012 where the project baseline of $465,931,135 and the construction schedule of 7 years and 3 months were adopted. The NSF request included 23% budget contingency and 7 months of schedule contingency. The project also identified technical descope items (LPM-72) equal to about 10% of the requested budget. The revised budget was submitted through Fastlane in June, 2012.

In April 2012, the DOE approved Critical Decision 1 for the LSST camera. This established the Camera cost range of $120,000,000 to $175,000,000, a preliminary Camera shipment schedule in December of (CY) 2019, and names the SLAC National Laboratory as the lead for the DOE LSST Camera effort.

In June 2013, the DOE Office of High Energy Physics provided new guidance on the funding profile for the Camera that fit within the CD-1 definition but required a revision to the integrated project schedule. The revised funding profile and year-long federal continuing resolution budgets in 2013 affected the Camera and LSST which caused a re-planning of the project baseline to $488.4M and a full construction schedule of 8 years and 3 months. The NSF request includes 20% budget contingency and has 7 months of schedule contingency (float) on the Camera Delivery and 13 months of float on the critical path for NSF deliverables. The DOE budget request includes ~44% cost contingency for the Camera. This baseline is being proposed for the Final Design Review in October 2013.

The LSST project maintains an extensive inventory of documents in a web-accessible, password-protected archive. This document and the references cited with "LPM" (LSST Project Management), "LSE" (LSST Systems Engineering), or similar prefixes are document handles within this archive. Access to the archive is managed by the LSST Project Management Office in Tucson, Arizona (https://www.lsstcorp.org).

2 Project Definition

2.1 LSST Research Objectives

The LSST survey capability will open new avenues of research in many diverse areas of astronomy and physics. However, in formulating the scientific requirements for the LSST facility, four broad scientific topics were selected:

- Constructing a census of moving objects in the Solar System
- Investigating the characteristics of the transient optical sky
- Charting the formation and structure of the Milky Way Galaxy
- Understanding the nature of dark matter and dark energy

These four science topics were chosen because they are the focus of cutting edge research that spans the universe from our own local neighborhood to distant galaxies: the formation of the Solar System, the evolution of galactic structure, and cosmology. Substantial progress in each area will require data of an unprecedented scale. These four science themes also place stringent and complementary requirements on image quality, astrometric and photometric precision, and the ability to identify and characterize objects that move or vary in brightness. Meeting the science requirements for these four topics will ensure that LSST will meet the requirements for a very broad range of other scientific programs**.**

The LSST Science Book (Strauss et al., 2009), which was authored by 245 individual scientists from the broad astronomy and physics communities, describes many of these programs in detail.

A scientific overview paper by the LSST Consortium (Ivezic et al., 2011) entitled, "LSST: From Science Drivers to Reference Design and Anticipated Data Products," describes the LSST project and scientific motivation for the LSST.

2.2 Science Requirements

The LSST science requirements are captured in the Science Requirements Document (SRD) (LPM-17). Specifically, the main science-derived requirements from the SRD are:

1. ***Image quality*** shall not be degraded by the hardware by more than ~10% from the median free-air seeing of 0.65 arcsec in the *r* band. The most stringent constraints on image quality are imposed by weak-lensing science, but excellent image quality is also necessary to meet the requirements on survey depth for point sources and for image-differencing techniques.
2. ***Photometric repeatability*** shall achieve 5 mmag precision at the bright end, with zero-point stability across the sky of 10 mmag and band-to-band calibration errors not larger than 5 mmag. These limits are required to achieve accuracy in photometric redshifts, separation of stellar populations, detection of low-amplitude variable objects, and the search for systematic effects in Type Ia supernova light curves.
3. ***Astrometric precision*** shall maintain the limit set by the atmosphere of about 10 mas per visit at the bright end (on scales below 20 arcmin). This precision is driven by the desire to achieve a proper motion accuracy of 0.2 mas/yr and parallax accuracy of 1.0 mas over the course of a 10-year survey.
4. ***A single visit duration****,* which includes two exposures for cosmic ray rejection*,* shall be no longer than about one minute to prevent trailing of fast moving objects and to aid control of various systematic effects induced by the atmosphere. A single visit shall be no shorter than ~20 seconds to avoid significant efficiency losses due to finite readout, slew time, and read

noise.

5. ***The filter complement*** shall include at least six filters in the wavelength range limited by atmospheric absorption and silicon detection efficiency (320-1050 nm), with roughly trapezoidal filter response and no large gaps in the coverage, in order to enable robust and accurate photometric redshifts and stellar typing. An SDSS-like *u* band shall be included for separating low-redshift quasars from hot stars and for estimating the metallicities of F/G main sequence stars. A bandpass with an effective wavelength of about 1 micron would enable studies of sub-stellar objects, high-redshift quasars (to redshifts of ~7.5), and regions of the Galaxy that are obscured by interstellar dust.
6. ***The revisit time distribution*** shall enable determination of orbits of solar system objects and sample SN light curves every few days, while accommodating constraints set by proper motion and trigonometric parallax measurements.
7. ***The total*** number ***of visits*** of any given area of sky, when accounting for all filters, shall be > 825, as mandated by weak-lensing (WL) science, the NEO survey, and proper motion and trigonometric parallax measurements. Studies of transient sources also benefit from a larger number of visits.
8. ***The co-added survey depth*** shall reach *r*~27.5, with sufficient signal-to noise ratio in other bands to address both extragalactic and Galactic science drivers.
9. ***The distribution of visits per filter*** shall enable accurate photometric redshifts, separation of stellar populations, and sufficient depth to enable detection of faint extremely red sources (e. g. brown dwarfs and high-redshift quasars). Detailed simulations suggest an approximately flat distribution of visits among bandpasses but with a slight preference given to the *r* and *i* bands because of their dominant role in star/galaxy separation and weak-lensing measurements.
10. ***Data processing, data products, and data access*** shall enable efficient science analysis without compromising accuracy and precision. To enable a fast and efficient response to transient sources, the processing latency should be less than a minute, with a robust and accurate characterization of reported transients.

2.3 Facilities necessary to obtain the project research objectives

The infrastructure and facilities that must be designed, built, integrated, tested, and commissioned are described in numerous project documents. The LSST Project Team submitted an MREFC Construction Proposal (Document-10548) in February 2011, with updates in October 2011 and June 2012. Chapter 4 of the proposal describes all components of the facilities required. Similar material is contained in Chapter 2 of the LSST Science Book (Strauss et al., 2009), and a full list of documents describing the project scope and requirements is available in the LSST Technical Baseline Classified Index (LSE-90).

The LSST optical design has been optimized to yield a very large field of view (9.6 deg^2), with seeing-limited image quality, across a wide wavelength band (350—1050 nm). Incident light is collected by the primary mirror, which is an annulus with an outer diameter of 8.4 m, then reflected to a 3.4-m convex secondary, onto a 5-m concave tertiary, and finally into three refractive lenses in the camera. This is achieved with an innovative approach that positions the tertiary mirror inside the primary mirror annulus ring, making it possible to fabricate the mirror-pair from a single monolithic blank using spin-cast borosilicate technology. The secondary is a thin meniscus mirror, fabricated in an ultra-low expansion material. All three mirrors will be actively supported to control wavefront distortions introduced by gravity and environmental stresses on the telescope.

The telescope mount is a compact, stiff structure with a fundamental frequency of nearly 10 Hz, which is crucial for achieving the fast slew-and-settle times that the survey strategy requires. The telescope sits on a concrete pier within a carousel dome that is 30 m in diameter. The dome has been designed to reduce dome seeing (local air turbulence that can distort images) and to maintain a uniform thermal environment over the course of the night.

The LSST Observatory will be sited atop Cerro Pachón in northern Chile, near the Gemini South and SOAR telescopes. This is a developed astronomical site, administered by the Associated Universities for Research in Astronomy (AURA). An artist's rendering of the facility on this site is shown in Figure 2-1.

The LSST camera provides a 3.2 Gigapixel flat focal plane array, tiled by 4k x 4k CCD sensors with 10-micron pixels. The sensors are deep-depleted, back-illuminated devices with a highly segmented architecture that enables the entire array to be read out in 2 seconds. The detectors are grouped into 3 by 3 rafts, each containing its own dedicated front-end and back-end electronics boards. The rafts are mounted on a silicon carbide grid inside a vacuum cryostat, with an intricate thermal control system that maintains the CCDs at an operating temperature of -80 C.

The entrance window to the cryostat is the third of the three refractive lenses in the camera. The other two lenses are mounted in an optics structure at the front of the camera body, which also contains a mechanical shutter, and a carousel assembly that holds five large optical filters. A sixth optical filter will also be fabricated and can replace any of the five via a procedure accomplished during daylight hours.

The rapid cadence of the LSST observing program will produce an enormous volume of data, ~15 terabytes of raw data per night, leading to a total database over the ten years of operations of several tens of petabytes. Processing such a large volume of data, converting the raw images into a faithful representation of the Universe, and archiving the results in useful form for a broad community of users is a major challenge for the project. The data management system is configured in three layers: an infrastructure layer consisting of the system software and computing, storage, and networking hardware; a middleware layer, which handles distributed processing, data access, user interface, and system operations services; and an applications layer, which includes data pipelines and products and the science data archives. There will be mountain summit communications infrastructure, base computing facilities, as well as a central archive facility and multiple data access centers. The data will be transported over existing high-speed optical fiber links from South America to the U.S.

The LSST observing strategy will be optimized to maximize the scientific throughput by minimizing slew and other downtime and by making appropriate choices of the filter bands given the real-time weather conditions. A simulator has been developed to evaluate this process, and during the construction phase of the project, it will be transformed into a sophisticated observations scheduler.

LSST will build an Education and Public Outreach (EPO) Center consisting of data, interfaces, and software tools to enable the use of LSST data products by a large, diverse audience of non-specialists. This EPO Center will be co-located with the central archive facility and be accessible through user interfaces tuned for our target audiences. Dynamic content, software tools, a collaborative workspace, and exemplary learning materials will also be developed and made available through a user-configurable EPO web portal to students and educators, online learners, and content developers at science museums and

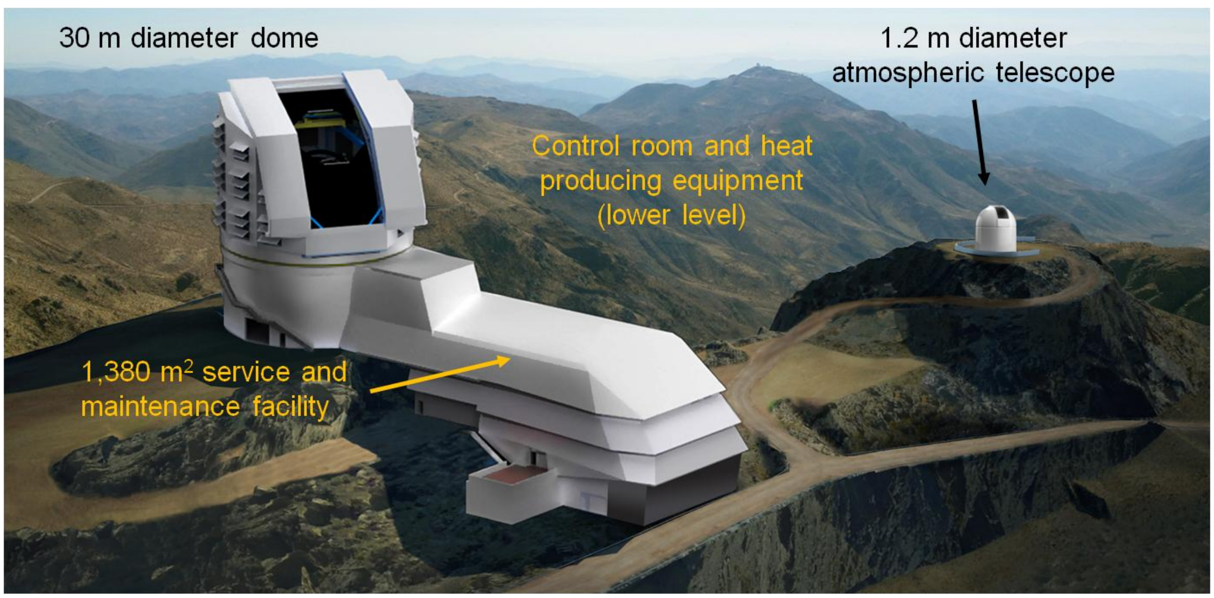

Figure 2-1: Artist Rendering of LSST Observatory on Cerro Pachón in Chile

planetariums.

2.4 Broader Impacts of LSST Project

The Education and Public Outreach system being developed with the LSST will enable an unprecedented impact on STEM education and science literacy. LSST will bring the dynamic and active Universe into the grasp of school children, lifelong learners and the general public in real-time so they too can participate in the discovery process. LSST is also making advances in managing large scientific data sets and in detector technology that will have broad impact not only in astronomy but in other fields as well.

LSST will make twenty trillion photometric measurements of twenty billion objects. The massive data produced by the LSST must be managed efficiently and analyzed in real time, thereby providing an important testbed for new approaches to data management. Key areas are: processing and analyzing the continuous data streams in a 24/7 fault tolerant manner; automated quality assessment and discovery algorithms; enabling the new discoveries coming out of the LSST to be made available to the public and researchers in near real time; and working with and managing large parallel data systems.

Researchers in astronomy, physics, mathematics, statistics, and computer science can all use LSST data for developing and testing tools for discovering fundamental new phenomena from massive data sets, assessing data quality automatically, visualizing and preserving data. In addition, several of LSST's astronomy-related problems, including, as one example, classification of transients, will drive multi-disciplinary research that requires a fusion of astronomy and physics with statistics and computer science.

LSST must employ innovative, large-scale database techniques including parallelization of queries, memory-based indices, and data partitioning and clustering. Also, LSST will use supercomputing technologies and will create a general-purpose data and algorithm-parallel framework that will be available as open source software, reusable for any high-performance, parallel scientific application.

Finally, LSST is employing advanced software engineering techniques for portability, open interfaces, and extensible data. As a result of LSST, the astronomy and physics communities will have an open source example to leverage for future projects. Data-driven modeling and discovery, which is an essential component of the LSST project, is an example of a developing new paradigm in science. Scientists must learn how to take advantage of machine learning and visualization techniques to extract information from the avalanche of data. The role of the experimental scientist increasingly will be as inventor of ambitious new search techniques and algorithms. Novel theories of nature will be tested through searching for statistical relationships across big databases. At the petascale and beyond, automated discovery of the unexpected is required both for data quality assessment and for scientific discovery.

The 3.2-gigapixel LSST camera will be the world's largest and will represent the gold standard in next-generation optical imagers. Recent advances in thick silicon imagers, plus application-specific integrated circuit (ASIC) technology, have made it possible to meet the demanding requirements of the LSST camera. The heart of this camera is an innovative CCD that has fast readout, high wideband sensitivity, low noise, and 4-side edge-buttable geometry. Our multi-stage program of imaging device development, including integration of the detectors with the electronics module, will result in self-contained, low-power imaging technology for applications that range from remote sensing to process control.

3 Project Organization

The LSST Project is a collaboration of sponsoring agencies and institutions organized to make the LSST a reality. The design and development phase of the project has been supported by the NSF, DOE, and LSSTC. Project plans and ongoing efforts are organized in consultation with, and reviewed by, the two federal agencies. Early success of the project is in large part due to the LSST Corporation and the non-federal funding that it provided for the acquisition of long-lead fabrication items. The organizational and financial support from each of these three organizations has been, and continues to be, key to the success of the LSST.

A single project office has been established to manage the LSST Project. The Project is organized to have a strong central structure with personnel directly responsible for the successful execution of the project. The ultimate success of the LSST depends on the contributions of many collaborators and contractors but a single LSST Director and a single LSST Project Manager are the keys to maintaining the coherence required to deliver a single integrated Project.

This section defines organizational relationships that bind the project into a single effort and describes the organizational structure of the LSST Project Office.

3.1 Governance and Institutional Responsibility

The institutional relationships established to make the LSST a successful public-private partnership are captured in a series of Memoranda of Understanding (MOUs). Table 3-1 lists the MOUs that define the roles and responsibilities of the key institutions charged with LSST Project delivery.

The National Science Foundation (NSF) is the lead US Federal Agency. The NSF and the Department of Energy Office of High Energy Physics (DOE) have signed an interagency MOU (Document-13847) to define their obligations as co-sponsors of the LSST Project. It establishes the NSF as the agency responsible for developing and delivering the telescope and associated support facilities as well as the entire data management system. The DOE is responsible for the development and delivery of the Camera System. The NSF and DOE have established a Joint Oversight Group (JOG), which maintains agency coordination and serves as a primary body for interaction with the Project Office.

Table 3-1: LSST Governance Agreements

Agreement	Document number
NSF and DOE MOU for LSST Cooperation	Document-13847
NSF Cooperative Agreement with AURA (Design)	Document-14949
DOE Approved Acquisition Strategy, naming SLAC as the lead national laboratory for the LSST camera project.	Acquisition Strategy for the Large Synoptic Survey Telescope Camera, Project ID SC-25-11-LSST, at SLAC National Accelerator Laboratory, 02/13/2012
AURA - SLAC	Document-11515
AURA - LSSTC	Document-11647

NSF funds for the LSST flow through Cooperative Agreements (Document-14949) with the Association of

Universities for Research in Astronomy (AURA). These agreements establish the LSST Project Office as an AURA-managed center for the construction phase of the LSST project. AURA is an experienced managing organization for NSF facilities and has agreed to take on full fiduciary responsibility and accountability under the cooperative agreement for LSST. Under this agreement, the AURA President and AURA Board of Directors are responsible for financial oversight of NSF funding of the LSST Project. In order to carry out its responsibilities, AURA has established the AURA Management Council for LSST (AMCL) to provide direct oversight of the Project.

LSSTC has established an MOU (Document-11647) with AURA to define its roles and responsibilities as a partner in the construction of LSST. The LSSTC will make its hardware assets (M1/M3, the M2 mirror blank, and prototype CCD sensors) available to the Project Office at no charge, and will continue to support non-construction-related efforts in community development and preparation for operations. The AURA/LSSTC MOU establishes additional cooperation in the governance of the project through use of the LSSTC Board for additional review of key mission efforts related to science requirements and community engagement. The LSSTC Board also selects four of the thirteen AMCL members.

The DOE has identified SLAC National Accelerator Laboratory (SLAC) as the lead organization for DOE efforts. SLAC manages a collaboration of other DOE national laboratories and high-energy physics groups at universities, who support the camera development, fabrication and delivery. Funds for the camera flow directly from DOE to SLAC, and fiscal responsibility for the DOE funds resides at SLAC. A significant element of this single project approach is the joint appointment and employment of the LSST Director by both AURA and SLAC. The LSSTC Board also recognizes the single LSST Project Office and has formally identified the LSST Director as having the authority and responsibility for LSSTC contributions to non-construction portions of the project, firmly establishing the LSST Director as the single authority for the overall LSST effort.

The AURA-SLAC MOU (Document-11515) focuses on the LSST Director and Project Manager as the lead managers responsible for system level decisions as well as managing the separately funded technical groups working on the LSST. The camera system remains a SLAC-managed DOE Major Item of Equipment (MIE) project that has distinct and clear Interfaces, both logically and physically, with the other LSST systems. The MOU describes the system-level performance requirements of the Observatory and defines the responsibilities of both Parties to recognize and participate in the LSST Project Change Control Board, Systems Engineering Group, Science Council, and project meetings. Each agency requires project fiscal and technical reviews that can occur multiple times per year. The entire project team will be available to support and participate as appropriate in all project reviews.

All MOUs are compliant with governing policies of the Agencies, AURA, and SLAC. Neither SLAC nor AURA will have fiduciary responsibility for the other’s funds, and will not exercise oversight nor draw administrative fees for that federally-funded work. Funding and scope will remain as agreed between the NSF and AURA and DOE and SLAC. The LSST Director will work with the JOG to resolve any cross-agency issues that may arise within the Project.

AURA, SLAC, and LSSTC have agreed to continue their collaboration at the completion of the construction phase by establishing a team for early operations of the LSST. AURA will submit a proposal for operations to the NSF several years before the transition to the operations phase and will continue, through appropriate agreements with SLAC and LSSTC, to maintain a single operations project supported by both Federal agencies and selected international partners. The NSF-DOE MOU includes the expected operations budgets for each agency and the anticipated budget from non-Federal funding that will be solicited by LSSTC from foreign sources.

3.2 Institutional Collaboration and Scope

The LSST Project is staffed by a team of national and international institutions expert in their fields, assembled to address the challenges in the design, development, construction, and eventual operation of the LSST. Included in the agreements with each funding agency is the definition of collaborators and subawards to be made in the execution of the work. Appendix B is the list of subawards to be made with NSF funding and includes both agreements for time and materials labor effort and agreements for software and hardware deliverables on fixed-price contracts.

Additional MOUs have been signed to extend the core collaboration. Table 3-2 lists these MOUs that constitute bilateral agreements between the LSST Project and the listed entities.

Table 3-1 Organization Agreements

Agreement	Document number
AURA-Chile	Document-11622
AURA-NCSA	Document-4245
LSST-Caltech	Document-4581
LSST_CNRS	Document-14953
LSST-LLNL	Document-3555
LSST-NOAO	Document-13848

An independent Site Selection Committee evaluated a suite of plausible sites for LSST, and recommended that the telescope should be located on AURA property in Chile (Document-1796). Permission to build and operate LSST facilities in Chile is governed by Chilean legislation and existing agreements between AURA and the Universidad de Chile, the entity charged with representing Chilean interests in negotiating with astronomy projects. AURA, on behalf of the LSST Project, has established the agreement with the Universidad de Chile (Document-11622) that will enable the LSST Project to operate in Chile within the framework of an official International Organization. This agreement sets forth conditions on the Project to deliver value to the Chilean astronomical community to replace the established 10% of observing time typically charged to telescope projects sited in Chile. As an official International organization, the LSST will enjoy tax-exempt status, a significant savings against Chile's normal Value Added Tax on imported materials.

The other MOUs listed in Table 3-2 serve to define the working relationships and agreements established to fulfill the LSST Baseline Plan. Two key institutional partners in the LSST Project effort are the National Optical Astronomy Observatory (NOAO) and the National Center for Supercomputing Applications (NCSA). The LSST Construction plan includes all the funding required to execute the plan, including the work at these institutions. However, the access to key facilities and personnel at these two NSF-funded centers required formal agreements. NOAO provides the Telescope and Site team for the Project and makes key facilities available for their use. NCSA will host the Archive and US Data

Access centers for the project, and also provide the personnel responsible for the LSST Data Management infrastructure effort.

3.3 Project Office Organization

The Organization chart for the LSST Project Key Management positions and advisory bodies is shown in Figure 3-2. This chart identifies each key position in the management and execution of the Project. This section summarizes the responsibilities for the listed positions and document LPM-103 includes the full job descriptions as well as the names of the individuals in each position.

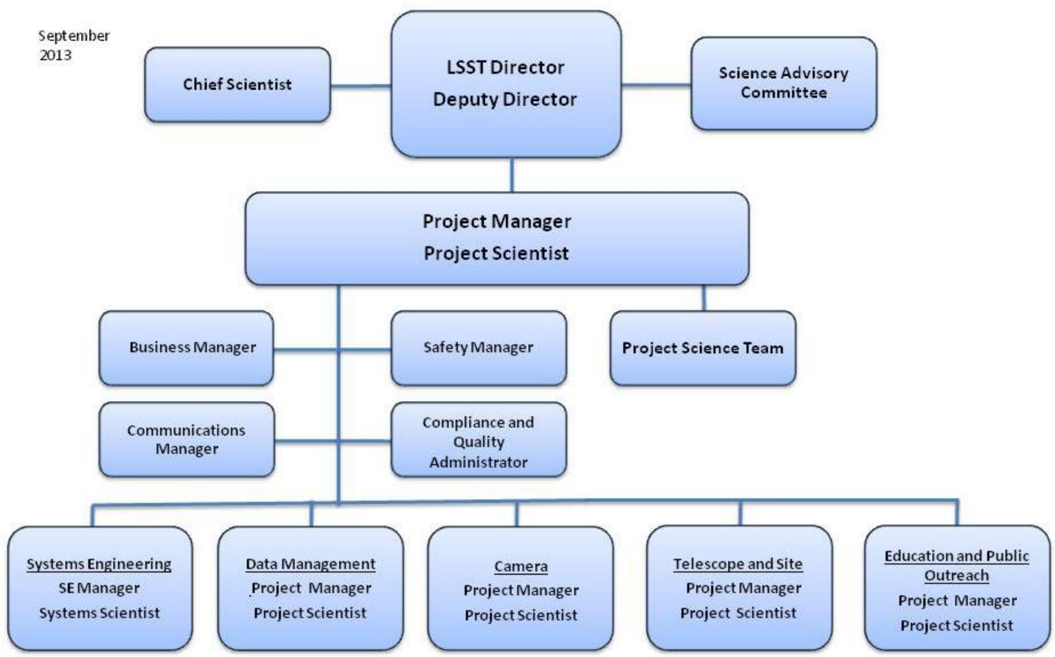

Figure 3-2: LSST organization chart

LSST Director: The authority for the construction of the LSST system is delegated to the Director, who is responsible for overall execution of the entire project. The Director is employed by both AURA and SLAC and is accountable to each organization for his/her performance. This delegation is described in AURA – SLAC MOU (Document-11515) and the AURA Management Plan for LSST (Document-13153) submitted to the NSF and is consistent with the Policies and Procedures of both AURA and SLAC. During construction, the Director is charged with ensuring that the scientific goals and management constraints on the project are met for both the project as a whole, and for the individual efforts funded by the two agencies. He or she will be the principal public spokesperson for the project and will represent the project to the funding agencies, the AURA and SLAC management boards, the LSSTC and the scientific community.

The AMCL conducts the search for the Director and submits their recommendation to the AURA Board for approval. This appointment also requires the approval of the NSF.

The LSST Deputy Director supports the Director in the execution of the overall LSST Project. The Deputy Director will complement the scientific interest of the Director to balance the wide interests of the LSST stakeholder community and will take responsibility for selected oversight roles, as negotiated with the Director.

The LSST Project Manager provides the programmatic and technical leadership and oversight of the LSST Project, the staff, and the activities pursued within the program. The Project Manager has the authority and responsibility for managing the project and controlling the integrated schedule and the NSF and LSSTC budget and contingency funds. The Project Manager ensures requirements and engineering specifications are consistent with the science objectives and requirements established for the LSST. The Project Manger is responsible for developing the technical designs and project plans necessary for the preparation and execution of the construction. This includes, but is not limited to, design and development, value engineering, construction budgeting, bidding, contracting, scheduling, staffing, and validation of the LSST. All LSST contracts and other substantial financial commitments will require the approval of the Project Manager.

The LSST Project Manager reports to the LSST Director and works closely with the Deputy Director and Project Scientist to ensure scientific goals are maximized within the existing budget and schedule. The LSST Project Manager is appointed by the AMCL upon the recommendation of the Director and approval of the NSF.

The Project Scientist has primary responsibility for understanding and optimizing the scientific performance of the LSST facility. The Project Scientist reports to the LSST Director, but takes input from, and may be assigned specific prioritized activities by the Project Manager in order to ensure that the funded science trade-off studies are well aligned with the project development schedule.

The LSST Business Manager oversees the administrative functions of the LSST Project Office and serves as the main interface between the LSST Project and the NSF on matters related to compliance with federal directives, especially NSF directives included in, or related to, the cooperative agreement between AURA and NSF. The Business Manger develops and supervises procedures for LSST contracts and grants, serves as the in-house Contracting Officer, and assists with submission, implementation, completion, and compliance of submittals for grants and contracts. The Business Manager serves as the liaison with AURA Central Administrative Services coordinating LSST business activities with AURA accounting, procurement, and human resources. He/she oversees all accounts payable/receivable and supervises all office administration to maintain economy and efficiency of operation. He/she also organizes and maintains administrative records, supervises support staff and serves as the point of contact for yearly A-133 Audits.

The Safety Manager is responsible for the LSST Safety Policy (LPM-18) and its implementation and helps Project management to ensure compliance. The Safety Manager reports directly to the LSST Project Manager and works closely with LSST subsystem managers, systems engineers, and the local safety managers/coordinators at each participating organization responsible for the implementation of local Safety, Health, and Environmental Program (SHE) Plans. The LSST Safety Manager has the authority and responsibility to report safety, health, and environmental issues and to make recommendations to the Project Manager, the Project Safety Council, and other leadership of the LSST Project, reporting directly to the LSST Director if necessary. The Safety Manager motivates the project team to value safety and to manage all risks in their area of responsibility

The Compliance and Quality Administrator works with the Project Manager and Business Manager on issues of Federal compliance and Project policy compliance. The CQA is trained in federal compliance and works with AURA award management and the Business Manager to verify that all activities of the Project are compliant and that all terms and conditions for the NSF Cooperative Agreement are being fulfilled. The CQA also works with the Project Manager to ensure that project policy is followed and works with the Systems Engineering team to ensure technical quality is achieved throughout the project. The Compliance and Quality Administrator reports to the Project Manager and has the authority and responsibility to report issues of compliance and quality directly to the Director if necessary.

The Communications Manager is responsible for communication within the distributed LSST project and to the public. The Communications Manager is responsible for the LSST websites and public information released to the community. All LSST Press Releases are reviewed and coordinated by the Communications Manager to ensure information accuracy, appropriate content, and timing. He/she reports to the Project Manager, supports the Director with sponsor and community communications, and supports the Project Office in progress reporting, meeting organization, and conference support.

The Systems Engineering Manager is the chief technical leader of the project. His or her responsibilities spans the entire project, including all the major subsystems (telescope, camera, and data management) and the whole life cycle of the project from the onset of construction to commissioning and hand-over to operations. The Systems Engineer is responsible for integrating the various technical contributions into an integrated system through interface design and specification, modeling, and simulations. The Systems Engineering Manager is also responsible for the technical direction and day-to-day priorities of the System Integration and Science validation periods, jointly referred to as the Commissioning period. The Systems Engineer reports to the Project Manager.

The Systems Scientist is a member of the systems engineering group and will ensure that acceptance testing and commissioning address the science requirements. To fulfill these responsibilities, the Systems Scientist participates in acceptance testing and, working with the Systems Engineer, will also develop the detailed plan for commissioning the LSST as an end-to-end system, from data acquisition to data distribution. The Systems Scientist reports to the Director, but takes input from the Systems Engineer.

Subsystem Project Managers and Scientists: The major technical tasks associated with building the LSST are distributed into subsystems: Telescope and Site, Camera, Data Management, and Education and Public Outreach. Each sub-system has its own experienced Project Manager and Subsystem Scientist. Each subsystem will also have the management structure and resources (including authority and budget within limits defined in Section 2.5) to manage its subsystem. The Subsystem Scientists are responsible for understanding and optimizing the as-built science performance of their respective subsystems.

The Chief Scientist is the principal advisor to the LSST Director with regard to science issues. Duties and Responsibilities will be defined to support the Director with scientific and community-related issues as they develop. The Chief Scientist is familiar with project history and the process that prescribed the science requirements.

The Project Science Team serves as an operational body that carries out specific scientific investigations as directed by the Project Manager and the Project Scientist. Its membership includes the Scientists listed as key personnel as well as other selected scientists on the Project who provide specific necessary expertise. The Project Science Team is constructed to provide scientific advice to the Project Manager, Project Scientist, and the LSST Director on critical scientific decisions as the project construction proceeds.

The Science Advisory Committee (SAC) is composed of external scientists with a vested interest in the LSST project but who are otherwise not formally engaged in the Project development and construction. It provides advice to the LSST Director on behalf of the community at large. This is the principal body that connects the LSST Project to the community. The SAC is chaired by a scientist, nominated by the LSST Director, but with approval of the AMCL and the LSSTC Board. The membership of the Science Advisory Committee is comprised of Chairs of Scientific Collaborations that have formed within the community to plan for and carry out scientific investigations with LSST in specific science areas, as well as elected representatives of the Chilean LSST Collaboration, and selected individual scientists as chosen by the Science Advisory Committee Chair in consultation with the LSST Director.

3.4 Delegated Authority Limits

The levels of financial authority for the execution of the project are granted to the Project Director by each Sponsoring agency through the specific funding agreement. The Project Director and Project Manager adhere to the full conditions and limits as defined by each agency. Table 3-3 indicates the level of delegated authority and the approval steps specifically for the NSF funding.

Table 3-3 Level of Delegated Authority and Approval Steps for LSST NSF Funding

Approval Process for NSF Activity	Identified in Plan for budget and sub- awardee	Identified in Plan for Budget but not by sub-awardee	Change in Baseline Plan[2,3]
$250,000 and below	Within Project Manager's Authority	Within Project Manager's Authority [1]	Approval for Contingency usage as required[2]
$1,000,000 and below	Within Project Director's Authority	Within Project Director's Authority NSF Cognizant Official Approval Required	Approval for Contingency usage as required[2] NSF Cognizant Official Approval Required
$3,000,000 and below	AURA President's Approval Required	LSSTC Board Consultation NSF Cognizant Official Approval Required	LSSTC Board Consultation Approval for Contingency usage as required[2] NSF Cognizant Official Approval Required

Greater than $3,000,000	AURA Board Approval Required	LSSTC Board Consultation AURA Board Approval NSF Cognizant Official Approval Required	LSSTC Board Consultation AURA Board Approval Approval for Contingency usage as required[2] NSF Cognizant Official Approval Required

(1) All foreign agreements must have NSF approval as specified in the Cooperative Agreement
(2) Requirements for assigning contingency to the program plan will be established and defined in the Cooperative Agreement for the Construction Project.
(3) The Cooperative agreement for design and development define the specific terms and conditions for changes to the technical scope and program plan for each funding year.

Authority for changes to the scope and schedule are addressed in Section 4.4. The following documents detail the policies for delegated financial authority for each funding source:

NSF Funding: Design and Development funding as authorized in CSA AST-1227061 (Document-14949) and in subsequent CAs that cover construction

AURA Policies and Procedures: (http://www.aura-astronomy.org/about.asp?aboutType=policies**)** define the Director's authority to act within the AURA Business systems

LSSTC Funding: The LSST Project Director will work with the LSSTC Board to develop its yearly budget. LSST project staff will assist with budget preparation on a cost-reimbursable basis.

All LSSTC budgets are submitted to AURA to validate that non-federal funding is programmed for effort outside the scope of the LSST Federal Project.

LSSTC has granted the LSST Director with $1,000,000 authority over LSSTC funds (Board Resolution 24 April 2013):

DOE Funding: LSST Director and Camera Project Manager authority over DOE funding is governed by the DOE Project Execution Plan (SC-25-11-LSST) (LCA-225)

The LSST Director and subsequently the LSST Project Manager have delegated further budgetary authority limits as shown in Figure3-3. This figure also captures the names of the staff members in each position in April 2013 and color shows how the delegation is defined for each funding source. All DOE authorization and spending terms and conditions are maintained by SLAC. All NSF and LSSTC funding is managed through the AURA's Reqless system (http://auracas.aura-astronomy.org) where authorization limits and delegated authority are managed for both normal business and temporary short term absences. A full definition of the succession plan for key LSST positions is described in the LSST Succession Plan (LPM-84).

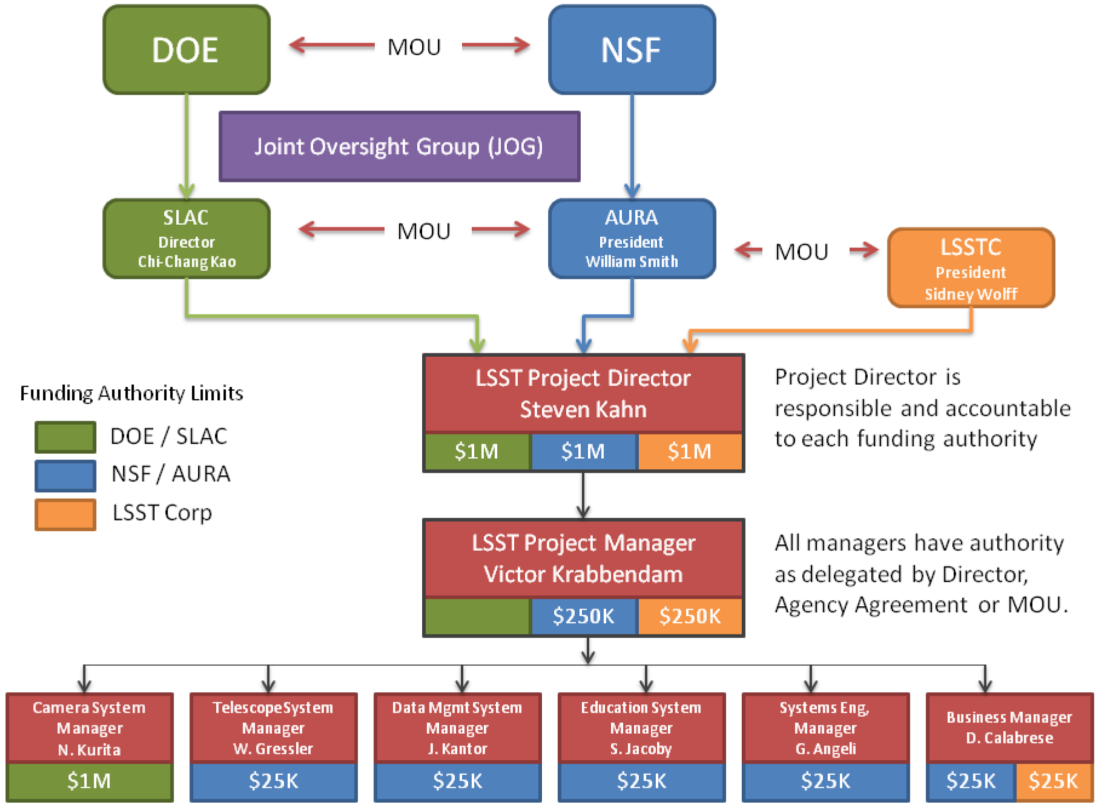

Figure 3-3 Delegated Signature Authority

3.5 Oversight and Compliance

The responsibility for compliance with federal regulations and the terms and conditions associated with the award of federal funding is with AURA for the NSF and SLAC for the DOE. The LSST Project office has a key role in the compliance with the NSF cooperative agreement and assists SLAC with the information they require. AURA Policy (AURA 2008) defines the roles and responsibility between AURA and the LSST Project Office. The LSST Director, Project Manager, Business Manager and Compliance and Quality Administrator have the primary responsibility for the compliance requirements of the Project for the NSF and LSSTC. The LSST Business Manager works with the AURA Grants Officer on cooperative agreement compliance, maintaining a detailed matrix of responsibilities for all terms and conditions. The Compliance and Quality Administrator has the primary responsibility to ensure that all purchasing, contracting, travel and general Project business is conducted within Federal Guidelines.

All Camera Project compliance is managed by SLAC in accordance with its policies and procedures as established with the DOE. The following provides some additional key oversight roles and responsibilities for the LSST Project to the NSF and LSSTC:

AURA Oversight: AURA's articles of incorporation set forth responsibilities for its Board of Directors that encompass its fiduciary responsibilities (http://www.aura-astronomy.org/about/sectionD.asp; see especially articles IV and V). NSF-awarded cooperative agreements are specific in recognizing these articles of incorporation and conveying fiduciary responsibility. The LSST Project recognizes that the AURA Board of Directors holds the ultimate authority and fiduciary obligation for all AURA activities. The Board oversees the business and program affairs of the corporation and is accountable to the AURA Members and the NSF for all aspects of the operation of AURA and its centers. They have the final authority to manage the programs and business of the corporation. The LSST Director and Project Manager have delegated responsibility and authority as outlined in Sections 3.3 and 3.4 and follow the procedures and processes to support the AURA Board and its oversight body, the AURA Management Council for LSST (AMCL). The AMCL is charged with the immediate oversight of the LSST to ensure the performance of the organization in meeting the contractual requirements of the NSF cooperative agreement.

Financial oversight: Principal tools for financial oversight are the delegated authority limits, regular status reporting, and annual audits. The delegated authority limits and tools for implementation are described in Section 3.4. The LSST Project produces an integrated monthly report with technical progress and plans for the entire project, including the effort supported by the NSF, the DOE and the LSSTC. This monthly report includes the financial status for the NSF funding and will be a full Earned Value report during construction (See Section 4.1 for further details). In compliance with the NSF cooperative agreement, the project produces quarterly and annual reports that document integrated technical progress and include, among other topics, the required NSF financial status reports. The LSST Camera project also produces regular reports directly for SLAC and the DOE. Finally, the LSST Project office was developed by building on the staff, policies, and procedures for the LSST Corporation, which has been subject to A-133 audits since 2004 and has never had a finding. As both an AURA center and the principal recipient of LSSTC funds, the Project office will continue to be subject to annual audits of the finances and procedures to satisfy both the AURA and LSSTC responsibilities.

All financial records for the Project will be open to financial managers at SLAC, the AMCL, the AURA and LSST Boards. Reports on the status of the camera project will be made to the AMCL, with emphasis on any issues that may impact the cost, schedule, and performance of the LSST system.

Scientific and Policy Oversight: The principal scientific and community-centered policies for LSST are overseen by the LSST Corporation Board. AURA and LSSTC have agreed to this division of responsibility to allow AURA to focus on detailed cooperative agreement compliance and oversight for the construction project while the LSSTC focuses on the science objectives and community interactions. AURA and LSSTC have agreed to a combined review of major procurements such that LSSTC provides an initial review focused on the science and community perspective before AURA reviews contracts for fiscal compliance. See Section 3.4 for further details on these levels of authority.

4 Project Controls

The project is organized into six primary work areas, the Project Office, Systems Engineering, and four subsystems charged with the development of the principal project deliverables; the Data Management Subsystem, the Camera Subsystem, the Telescope and Site Subsystem, and the Education and Public Outreach Subsystem. As defined in Section 3.3 each subsystem has a Subsystem Project Manager with the responsibility and delegated authority to manage the development of their subsystem to meet the requirements within the planned schedule and costs. Each subsystem also has a Subsystem Scientist responsible for the scientific analysis and interpretation of requirements and design choices to ensure the LSST meets the specific science requirements and fulfils the maximum scientific potential within the constraints of the Baseline plan. Systems Engineering is staffed and organized like a subsystem, but their principal efforts are the configuration management of the entire system through requirements and interface definition. In the later stage of the Project, Systems Engineering is responsible for the Commissioning effort, which includes system integration and science verification.

The Project executes the development of the LSST as defined in this PEP and in a series of additional documents (see Figure 4-1). This section continues with a brief overview of the key policies and tools described in these documents, which enable the clear and transparent execution of this project.

- Project Execution Plan (LPM-54)
  - LSST Project Administration Policies (LPM-97)
    - Communications Handbook (LPM-82)
    - IT Cybersecurity Plan (LPM-102)
    - Disaster Recovery Plan (LPM-101)
    - Succession Plan (LPM-84)
    - Document Management Plan (LPM-51)
  - Systems Engineering Management Plan (LSE-17)
    - Technical Baseline Classified Index (LSE-90)
    - Verification and Validation Process (LSE-160)
    - Interface Control Process (LSE-151)
    - Commissioning Plan (LSE-79)
    - Decommissioning Plan (LPM-71)
    - Reviews Definitions Guidelines Procedures (LSE-159)
    - Spare Parts and Consumables Policy (LSE-170)
  - Contingency Management Plan (LPM-61)
    - Technical Scope Options (LPM-72)
    - Risk Management Plan (LPM-20)
  - Quality Assurance Plan (LPM-55)
  - LSST Safety Policy (LPM-18)
    - Site Environ-mental and Cultural Plan (LPM-52)
    - Hazard Analysis (LPM-49)
    - Local SHE Plans https://www.lsstcorp.org/safety/home
  - Change Control Process (LPM-19)
    - Change Control Web-based Workflow https://www.lsstcorp.org/groups/ccb/
  - Project Controls Management Plan (LPM-98)
    - Cost Estimating Plan (LPM-81)
    - WBS Structure (LPM-43)
    - WBS Dictionary (LPM-44)

Figure 4-1 LSST Policy Documents

4.1 Project Management Control System (PMCS)

A Project Management Control System (PMCS) is maintained to track the budgets, schedule, and resources necessary to complete the LSST Construction. The PMCS is built on the Primavera P6 software package and has been customized for LSST. The PMCS contains the costs and schedule as well as the scope, resource allocations, work descriptions, the basis of estimates, and the activity-based risk assessment evaluation. The PMCS maintains data in the base year value as well as the then-year costs. The LSST PMCS will also be coupled with Deltek Cobra to support an earned value management system (EVMS) that correlates the LSST plans with the actual costs imported from the AURA accounting system.

The AURA accounting system provides the labor dollars and hours, as well as capital commitments and expenditures, within two weeks of the close of a month allowing Cobra integration for early warning of problems with cost and/or schedule so that corrective action can be taken. The LSST project has clearly defined goals and activities that extend over several years that must be completed within cost and time limitations. The EVMS will include standard graphical tools to support the monthly reports with the trend lines and variance information to determine where any actions are required.

The LSST Camera Project led by SLAC uses a DOE certified PMCS. The LSST PMCS imports schedule and status data from the Camera PMCS for project wide management, but the formal DOE reporting and full DOE EVMS reporting is developed from the Camera PMCS directly.

The LSST Process Controls Management Plan (LPM-98) further defines the LSST system and how it is administered.

4.2 Work Breakdown Structure (WBS)

All project activities are identified within a work breakdown structure provided in LPM-43. This product driven WBS, down to level 2, is shown in Figure 4-2. The full WBS dictionary is presented in LPM-44. Documents LPM-43 and 44 are outputs from the LSST PMCS where the WBS is administered and maintained. The PMCS system includes the necessary notebook entries in its database to include a full description of each WBS as well as a full description of the scope of each activity.

LSST-CCM LSST Construction and Commissioning

WBS Code		WBS Code	
01C Project Management Office Construction		**04C Telescope and Site Construction**	
01C.00	PMO Level 2 Milestones	04C.00	T&S Level 2 Milestones
01C.01	LSST Project Office	04C.01	Telescope System Management
01C.02	Site Office	04C.02	Telescope System Engineering
01C.03	Safety and Environmental Assurance	04C.03	Summit Facilities and Infrastructure
01C.04	Facility Administration	04C.04	Dome
01C.05	AURA	04C.05	Telescope Mount
		04C.06	Mirror Systems
02C Data Management Construction		04C.07	Wavefront and Alignment Sensing
02C.00	DM Level 2 Milestones	04C.08	Calibration System
02C.01	System Management	04C.09	Reflective Coating System
02C.02	System Engineering	04C.10	Observatory Control System
02C.03	Alert Production	04C.11	Telescope Control System
02C.04	Data Release Production	04C.12	Utilities and Support Equipment
02C.05	Science User Interface and Analysis Tools	04C.13	Base Facility and Infrastructure
02C.06	Science Data Archive and Application Services	04C.14	Telescope Integration and Test
02C.07	Processing Control and Site Infrastructure		
02C.08	International Communications and Base Site	**05C Education and Public Outreach Construction**	
02C.09	Data Management System Integration and Test	05C.00	EPO Level 2 Milestones
		05C.01	System Management
03C Camera Construction		05C.02	EPO Database and Data Access Services
03C.00	Camera Level 2 Milestones	05C.03	Infrastructure for Citizen Science
03C.01	System Management	05C.04	Classroom / Online Research Toolkit
03C.02	Systems Engineering and Design Integration	05C.05	Visualization including Science Museums
03C.03	Science Raft System	05C.06	User Interfaces
03C.04	Corner Raft System		
03C.05	Optics	**06C Systems Engineering and Commissioning**	
03C.06	Camera Body and Mechanisms	06C.00	Systems Engineering and Commissioning Level 2 Milestones
03C.07	Cryostat	06C.01	Systems Engineering and Commissioning Management
03C.08	Control System and DAQ	06C.02	Acceptance Testing
03C.09	Camera System Integration and Test	06C.03	Early System Integration and Test
03C.10	Camera Observatory Integration & Test	06C.04	Full System Integration & Test
		06C.05	Science Verification

Figure 4-2: LSST WBS to Level 2

4.3 Risk Management

LSST has established a risk management plan designed to support a forward-looking and continuous effort to identify, track, and manage risks. Document LPM-20 is the LSST Project Risk Management Plan, which fully describes the analysis process and registry methodology for project risk, budget risk, schedule risk, and technical risk.

The Project uses an on-line system for administering the LSST Risk Register. It is available at https://www.lsstcorp.org/riskmanagement_index.php where access to the risk database, key documents, and references are available. The plan outlined herein is intended to:

- Provide methods to identify risks

- Provide criteria to evaluate risks in terms of cost, probability, and consequence
- Outline the process of risk handling or mitigating potential adverse events
- Provide a formal methodology for risk monitoring in terms of review and reporting
- Provide a formal methodology for evaluating and prioritizing mitigation activities
- Provide a format for documenting the process and results of risk management

The Risk Register is organized by each major subsystem of the Project, consistent with Level One of the WBS. The subsystem managers and their teams are responsible for the maintenance of the registry and for regular assessment. As the Project moves into the formal construction phase, the registry is focused on the risks that might affect successful execution of the baseline plan. In many cases the plan already includes mitigation efforts so the success of these tasks is also evaluated. In order to be effective, the Risk Register is kept brief and to the point so it quickly conveys the essential information (as appropriate, separate documentation detailing mitigation strategies and costing may be referenced for major risks). The Risk Register is reviewed and updated regularly so it can support an evaluation of risk exposure through the ongoing progression of the project. The tool has been built to track risks that are 1) active, 2) retired, 3) subordinate, and 4) abrogated. Subordinate risks allow each subsystem to use the tool for lower level analysis and communication within sub-teams, and the abrogated class ensures nothing is lost in the ongoing risk management process.

The Project Manager is responsible for the risk register and works with each subsystem manager to adjust the cost and risk scoring to an equivalent basis. Risks are manually reviewed in this manner to ensure that entries developed by many personnel across the project are captured and assessed with similar leveling, allowing for project-wide integrated assessment of risk and exposure.

Safety and health of personnel are included in the Risk Management process. However, detailed safety assessment is separately tracked in the Hazard Analysis and Hazard register discussed in Section 4.5.

4.4 Contingency Management

The LSST Project incorporates specific budget, schedule, and technical reserves in the scope supported by each Federal Agency. These are explicitly reported to the agencies and the procedures for usage and reporting are consistent with the specific Agency agreements and the levels of authority described in Section 3.4. Details of the Camera Project contingency management are available in the Camera Project Execution Plan (LCA-225) and Camera Project Management Plan (LCA-226). The remainder of this section focuses on the contingency management for the NSF-funded portion of the project.

The Project Manager has the direct responsibility for the allocation of contingency in accordance with funding agency policy for the budget allocation, schedule float, and technical margins. All such changes are coordinated with the Director. The Change Control Board (CCB) will consider and recommend disposition of requests for changes to system-level designs and interfaces, as well as proposed draw-downs on project cost, schedule, and/or technical reserves. All such changes, even those within the authority of the Director and Project Manager, are administered through the CCB (https://www.lsstcorp.org/groups/ccb) to involve the senior managers and scientists in the re-working of the plan. The following further describes the three types of contingency and the approach to managing them:

Budget Contingency: The initial level of NSF contingency funding was estimated at the activity level using a standardized risk-scoring methodology described in the LSST Cost Estimating Plan (LPM-81). Activity-based estimates of cost and resources, along with the documented basis of estimate and risk scoring, were prepared by members of the subsystem teams, who consulted technical experts and outside contractors as appropriate. The risk scores generated estimates of contingency based on the activity base cost. All activity contingency was summed to reach a proposed total contingency pool. This basis for estimating the necessary contingency will be maintained through the duration of the project as a consistent measure of remaining activity based contingency.

The project has also developed a risk-based cost exposure from the risk register described in Section 4.3. The risk-based approach is a topical assessment of the risks and includes a Monte Carlo analysis to inform the Project Manager of the risk exposure throughout the course of the project.

Both assessments of the possible uses for contingency provide a target burn-down of contingency and a lien list of events that the Director and Project Manager can review when considering any changes to the baseline plan. The Project Manager maintains a log of changes to the baseline PMCS to keep a constant record of the budget reserves, and the EVMS reporting provides a monthly up-to-date accounting as described in the PMCS Management Plan (LPM-98).

Schedule Contingency: The PMCS described in Section 4.1 includes an integrated project schedule (IPS) for the entire construction, commissioning, and start of operations phases. The IPS includes all the necessary logic to derive critical paths and establish the float on the activities. Milestones are captured for the entire project. The IPS also includes the necessary data from the Camera Team to support the interactions and delivery dates, to and from, for the Camera project. The full Camera schedule is maintained within the SLAC based Primavera system but monthly updates will be transmitted to the LSST IPS to ensure coordination of the single integrated project. The IPS has a Monte Carlo module for analysis of schedule scenarios to further support critical path and general schedule impact assessments. The total float included in the schedule varies depending on subsystem, but each subsystem has a schedule that it can be expected to meet. The Project baseline has appropriate float to establish a schedule contingency.

The schedule float in the IPS is budgeted explicitly where the plan requires staff continuity but funds to cover the integrated critical path float are not. The Integrated Project schedule float between the early delivery and the late delivery will be funded by the contingency budget and will be allocated by the Project Manager if required. The lien list and contingency planning discussed above includes the necessary staff costs to cover the necessary float.

Technical Reserves: Specifications in the LSST Science Requirements Document (LPM-17) and the flow down system requirements documents (LSE-29 and LSE-30) are designated as minimums, design points, and goals. The reference design is based on the design point specification. The difference between the design point and the minimum is the technical reserve. With appropriate systems analysis, trades can be made among the requirements to control cost and schedule risk while preserving overall system performance. If necessary, the technical requirements can be relaxed to the design minimum with only marginal loss in total system performance. No such changes to the technical baseline will be made without Federal Agency approval for a baseline change.

The aggregate performance of the LSST is also represented as a set of metrics that support the specific science requirement minimums, design, and goal values. These metrics and the tools for analysis are utilized for all cases of requirement deviations and proposed baseline changes to support a consistent measure against which to assess mitigations for issues that develop during the course of the Project.

4.5 Safety and Health Management

The “LSST Safety Policy” is available as LSST document LPM-18. The LSST Project is committed to achieving the highest performance in safety, health, and environmental management practices with the aim of creating and maintaining a safe and healthy working and operating environment. The Safety Program focuses on personnel and equipment safety throughout the design, construction, and operation phases of the project. The Program addresses working conditions and procedures, as well as the management structure and design features that impact safety throughout the LSST Project.

The LSST Project is executed by several teams in distributed locations and with different funding sponsors. This LSST Safety Program covers all LSST Project efforts while recognizing and requiring that local Safety, Health, and Environmental policies be in place at participating institutions.

The safety policy lays out a foundation for project development and operations intended to establish a culture where the safety and health of personnel and equipment is a paramount concern, individuals are empowered, and management is structured to encourage and promote safety in all elements of the project. In particular, LSST is committed to

- Promote a work environment based on continuous improvement, employee involvement, ownership, teamwork, education, and leadership;
- Reinforce the need for people to care about the people that they work with;
- Promote the philosophy that safety is not a priority that can be reordered, it is a value associated with everything that we do;
- Recognize, reward, and reinforce our safety, health and environmental achievements, innovations, and behaviors;
- Address all known risks to people, property, and the environment;
- Exercise vigilance to ensure compliance with all applicable, laws, regulations, and best management practices;
- Integrate safety, health, and environmental considerations into project planning, design, construction, and operations to minimize loss; and
- Conduct sustainable programs to minimize pollution to the environment, to protect material resources, honor cultural resources, and minimize our impact to biota.

LSST expects local SHE plans to comply with all applicable safety, health, and environmental regulations and requirements in Title 29 of the U.S. Code of Federal Regulations (CFR) (NARA 2012) including Part 1910, "OSHA Safety and Health Standards for General Industry" and Part 1926, "Safety and Health Regulations for Construction," 49 CFR Federal Motor Carrier Safety Administration, 40 CFR Protection of Environment, and others that may apply. LSST considers the above CFR’s as minimum standards. Plans governing work in Chile will comply with the requirements of this document and other Chilean laws such as Safety Law No 16.744 and other Chilean Standards (Normas Chilenas).

The LSST safety program requires a clear line of responsibility and authority to ensure proper implementation and verification. The Project has a single Safety Manager, who manages all aspects of the program. The Safety Manager is assisted by a standing council of safety professionals and other team members who will provide the review and assessment required within the program and support the Safety Manager as needed during the project. The Safety Council also provides direct reports to the Project Manager and Director as necessary to inform the highest level of authority to ensure that safety remains the highest priority of the program.

An important part of the Safety program that plans for safe conditions during the execution of the construction as well as the later operations and maintenance, is a rigorous Hazard Analysis Program (LPM-49). The key to the Hazard program is the process of design and operation evaluation performed by the engineers, technicians, safety managers, and subject matter experts during the development process. This assessment is captured in a Hazard register to support the management of these issues and the proper completion of mitigation strategies.

4.6 Systems Engineering Approach

The LSST Systems Engineering Management Plan (SEMP) (LSE-17) describes activities, processes, and tools that will be used by the LSST systems engineering team to support the design and development, construction, and commissioning phases of the project. The objective of the Systems Engineering effort is to assure successful development of the LSST system primarily by defining clear and accurate system and interface requirements and verifying system compliance to these requirements.

The SEMP is applicable to all Systems Engineering tasks and activities to be performed in support of the LSST project. The SEMP will evolve as the structure of the LSST project transitions from the Design & Development Phase through the Construction Phase to the Commissioning and Operations phases.

The Systems Engineering Manager provides technical leadership and directs the development work of the LSST subsystems through the development and tracking of system requirements, system budgets and reserves, interface control requirements and documents, and performance and verification specifications. The Systems Engineer also works with the Systems Scientist and the subsystem project scientists to develop an integrated commissioning and science verification plan. The Systems Engineer is part of the Project Management Office and reports to the overall Project Manager.

Each LSST subsystem supports the project systems engineering effort by providing a subsystem Systems Engineer or systems engineering representative to the project systems engineering team. This person will contribute to the project systems engineering effort through development of requirements, specifications, and test plans necessary for that LSST subsystem and overseeing the subsystem's verification process.

The project systems engineering team has a particular responsibility to coordinate the development of inter-subsystem interface requirements and specifications and has a key role in configuration management and change control as described in Section 4.8.

4.7 Quality Control Plans

The LSST quality control and assurance plans are detailed in the LSST Project Quality Assurance Plan (LPM-55). Implementation of the quality assurance plan is the responsibility of the Compliance and Quality Administrator who reports directly to the Project Manager.

The Quality Assurance Plan aims to ensure that the LSST provides a broad scientific community with research quality data over the life-time of the project. The quality of the LSST components will be measured at the program level by implementation of the policies and procedures described in LPM-55. The Compliance and Quality Administrator will ensure that policies and procedures are followed and will work with systems engineering and the subsystems to verify that the data, hardware, and services provided by the LSST team and subsystems meet or exceed their requirements. Quality functions are integrated into the entire PMO and LSST team, allowing for a seamless approach and the institutionalization of quality into the project. Specific roles of various managers are presented in LPM-55.

Any individual involved in the project who becomes aware of an activity or workmanship that he or she believes to be of inadequate quality is responsible for bringing the relevant issue(s) to the attention of his or her supervisor. It is the responsibility of the supervisor to investigate the situation, to communicate the problem to the Project Manager, and to take appropriate corrective actions as required. All Managers and the Compliance and Quality Administrator have the authority and responsibility to stop work of inadequate quality if deemed appropriate.

The training program for project personnel will be commensurate with the scope, hazards, and complexity of their job functions. The responsible supervisor or manager establishes, by means of a position description, the minimum requirements with respect to education, experience, and other initial qualifications, for positions that require performance of quality-affecting activities. The supervisor/manager makes a determination of the candidates' initial qualifications as compared with the minimum requirements and schedules additional training as appropriate.

Prompt action will be taken to rectify and prevent recurrence of significant conditions adverse to quality, environment, safety, and health. The decision to initiate any corrective action will also be based upon an evaluation of the seriousness, and the adverse cost and schedule impact of the problem relative to the cost and difficulty of its correction.

The primary responsibility for eliminating or minimizing defective elements and nonconforming articles and for correcting conditions that have initiated or would initiate these problems rests with the individual group responsible for performing the tasks or producing the articles. The cognizant manager working in conjunction with the Compliance and Quality Administrator and/or Safety Officer is responsible for seeing that all appropriate corrective actions are adequate and taken in a timely manner. If the cognizant manager, Compliance and Quality Administrator, or Safety 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. If at any time, there are quality, compliance, or safety concerns that are not being addressed in a satisfactory manor by the Project Manager, the Compliance and Quality Administrator and the Safety Manager have the responsibility to bring such matters to the attention of the Director, and furthermore to the President of AURA if deemed necessary for proper attention.

The quality assurance objectives that are outlined in the QAP shall be regularly monitored by the Compliance and Quality Administrator and the Safety Manager on behalf of, and routinely reported to, the Project Manager. The Safety Manager has stop work authority in this role and will report directly to the Project Manager to ensure that appropriate corrective actions are implemented for any deficiencies that are discovered.

4.8 Configuration Management and Change Control

LSST Configuration Management is the process through which the Project documents the functional and physical characteristics of the Observatory, controls changes to those characteristics, and provides information on the state of change actions. The CM process involves all levels of management responsibility and consists of four ongoing stages: Configuration Identification, Configuration Change Control, Configuration Status Accounting, and Configuration Verification.

Configuration Management for LSST is administered by the Systems Engineering Group. A detailed description is found in the Systems Engineering Management Plan (LSE-17), and the details of the Change Control Process are found in LPM-19. The intention of the process is to ensure that

- Baselines are defined and documented;
- Documentation is identified, released, and controlled;
- The Configuration Control Board is defined, established, and functions to CM guidelines;
- Types and metadata structures for documentation are identified;
- Storage procedures for documentation are defined;
- Changes to the baseline are reviewed, implemented, tracked and documented; and
- Distribution and archiving processes are defined.

CM is the responsibility of the LSST Project Office and must be supported by all LSST team members. The Project Manager (PM) has overall responsibility for CM and for ensuring that all project configuration items (CIs) are identified and controlled. The PM is responsible for the Change Control Board (CCB) and acting on all change requests that are processed by the CCB, both recommended and not recommended. All actions are reported to, and approved by the LSST Director, and all actions will follow the authorities defined in Sections 3.3 and 3.4 and the DOE LSST Camera Project Execution Plan.

The Systems Engineering Manager leads the CCB administration. He/she is responsible for the execution, technical oversight, and coordination of configuration control activities. The LSST Document Specialist is responsible for configuration status accounting and works with the SE and PM on configuration verification. The membership and full responsibilities of the CCB are detailed in LPM-19.

At appropriate times, CI documents, baseline configurations, and requirements may be modified. If the author, Subsystem Manager, and SE determine that the proposed change requires CCB approval, then the SE will convene a CCB meeting. The CCB is primarily responsible for reviewing all Change Requests (CR) based on the impact on system-wide costs, schedule, and technical performance. The CCB may also be called on to evaluate externally-initiated change requests and requests for deviation or waiver. These may originate with external review boards, subcontractors, or the Board of Directors. Also, the CCB is required to review all proposed changes before passing them on to the PM.

LSST is using model-based systems engineering methodology for developing the overall system architecture coded with the Systems Modeling Language (SysML). This process is fully defined in LSE-17. SysML promotes the recursive development of, and defining the relationships between, requirements, logical & physical definitions, and overall behavior (activities and sequences) at successively deeper levels of abstraction and detail. As the modeling process develops more detailed requirements and specifications, it tracks traceability and allows specification of all system interfaces, physical and information flows, and clarification of the logic and control flows governing system behavior. The resulting integrated model database is used to generate all Requirements Baseline documentation below the SRD (LPM-17). The content in the model serves as the point of control for these CIs through the tools that generate the documents that are reviewed for approval.

All CI's are represented by documents controlled by the LSST project and managed with the LSST DocuShare Archive. The LSST Document Management Plan (LPM-51) provides the general approach to DocuShare use for LSST. All CI's must be identified by an LSST document number to ensure that they, and any changes to them, are tracked and maintained through the life of the project.

All documents (defined as any file in the LSST DocuShare electronic archive system regardless of type, though not including engineering CAD files) will be archived in the general LSST DocuShare system, following an established integrated organizational structure and workflow process.

4.9 Acquisition Plans, Sub-awards and Subcontracting Strategy

An important strategy for controlling cost risks that will be utilized by LSST whenever possible is firm fixed-price contracts. Essential to the success of this approach are clear and complete specifications, so that change orders are either not required or are held to a minimum. Another lesson learned from other big telescope projects is the importance of close monitoring of contractor work. Contracts will be structured with verifiable milestones and will specify the information to be provided to the project office so that early identification of issues concerning performance, cost, and schedule can be identified. All contracted effort is managed with payment milestones based on completed work. Data Management also makes heavy use of sub-awards with institutional partners that have established a track record of performance over 8 years. As such, they have been pre-validated for ability to perform their construction roles.

LSST follows AURA procurement policy (AURA 2008), which adheres to policies and procedures for the procurement of goods and services as required by the applicable Code of Federal Regulations (CFR) (NARA, 2012), Federal Acquisition Regulations (FAR) (http://www.acquisition.gov/far/), the Uniform Commercial Code (UCC), and other federal agency terms and conditions including, but not limited to, the NSF Grant Conditions (GC-1) (NSF, 2013b), NSF Cooperative Agreement Financial & Administrative Terms and Conditions (CA-FATCs) (NSF, 2013a), applicable foreign law when necessary due to project location, and standard acceptable business practices in the issuance of purchase orders sub-awards and contracts. The purpose of these procurement procedures is to (1) maximize value received in procurements; (2) ensure compliance with government conditions; and (3) promote efficiency in procurements by standardizing processes as much as practicable.

Competition: In accordance with provisions in 2 CFR Part 215.43 (OMB A110 - Uniform Administrative requirements for Grants and Agreements with Institutions of Higher Education, Hospitals and other Non-Profit Organizations) and other applicable federal regulations as referenced in individual contracts or cooperative agreements, all procurement transactions shall be conducted in a manner to provide, to the maximum extent practical, open and free competition. AURA procurement staff, the LSST Project Manager, and the LSST Business Manager are alert to organizational conflicts of interest as well as non-competitive practices among contractors that may restrict or eliminate competition or otherwise restrain trade.

AURA and LSST procedures ensure objective contractor performance and eliminate unfair competitive advantage. Contractors that develop or draft specifications, requirements, statements of work, invitations for bids, and/or requests for proposals shall be excluded from competing for such procurements. Awards shall be made to the bidder or offeror whose bid or offer is most responsive to the solicitation and is most advantageous to the Project in terms of price, quality, and other factors specifically identified in the solicitation. Solicitations shall clearly set forth all requirements that the bidder or offeror shall fulfill in order for the bid or offer to be evaluated by the recipient. Any and all bids or offers may be rejected when it is in AURA's or LSST's interest to do so.

AURA's procurement policies will be updated regularly to ensure that they comply with government regulations. These policies will be easily accessible by all staff. In addition, the LSST project will ensure that all procurement staff is adequately trained in these policies and in applicable federal guidelines.

4.10 Spare Parts and Consumable Material Policy

The LSST Project will design, build, and deliver the system defined in Section 2 to meet the performance and reliability as defined in the series of requirements documents described in that Section and the Systems Engineering Management Plan (LSE- 17). Critical requirements of the LSST project relate to the time domain for detection of transients and the completeness of the observations within the 10-year survey. These performance criteria drive up-time and life cycle requirements that propagate to all elements of the system. The appropriate amount of spare, additional, and overage material to successfully complete the construction and to maintain the system will be analyzed individually for impact on construction cost and schedule, operations cost and schedule, the ability to obtain the items in the future and other manufacturing/performance considerations.

LSST will include lifetime, overage, and auxiliary parts and materials as defined in LSE-170 for the NSF MREFC scope and LCA-398 for the DOE funded scope. The Project uses the two documents to account for a difference in terminology and the differences in the scope of the MREFC and MIE projects. LSST Systems Engineering works with the entire LSST team to verify the completeness of the parts and materials to be delivered. The following criteria will be used to develop the plan for including additional parts and materials into the baseline for the project:

a) Lifecycle analysis indicates a high likelihood of failure before the system is delivered to Operations.

b) Lifecycle analysis indicates a high likelihood of failure during operations and the item has a high probability of obsolescence and a critical and specialized configuration.

c) Custom manufacturing and assembly losses require an overage order for low risk in achieving the required number of units.

d) It is cost favorable to the Government to include an overage amount, or extra units, of custom manufactured parts that also have a reasonable likelihood of failure during the operations phase. For example, custom electronics, circuit boards, and custom wound motors.

LSST will deliver all spare, auxiliary, and overage hardware with the operational system. The LSST Spares and Overage Parts (LSE-170) and the corollary LSST Camera Auxiliary Units and Overage Plan, (LCA-398) will be maintained for the detailed listing of this hardware.

The LSST will separately identify and provide detailed replacement information for all hardware that is expected to fail during Operations but that will not have spares delivered under the construction project. The Operations Plan (LPM-73), described in Section 6.5, will include specific details of hardware that needs to be refreshed during operations, added during operations, or potentially changed due to failure during operations. The following criteria will be followed for equipment and hardware that will be in this category:

1) Hardware that is expected to improve in performance or be lower in cost over time and that is not needed at the beginning of Operations. The LSST Data Management Design Document (LDM-148) includes a just-in-time operational model to add computational and storage capacity as the data volume expands during operations since the cost per unit of storage goes down over time.
2) Hardware with insufficient performance life for the full operations period but that is common hardware that is expected to improve in performance or lower in cost over time. For example, the Data Management system operations model includes computer hardware replacement throughout operations.
3) Hardware that is ubiquitous, common, or otherwise best purchased as needed despite some probability of failure during operations.

The LSST Project Office will purchase consumable materials commensurate for completion of the appropriate funded phase of work. The MREFC budget will be used to purchase supplies and materials sufficient to complete the construction, integration and commissioning of the system. Materials necessary for operations will be specifically identified, and residual materials will be delivered to Operations but not purchased with the intent to support the operations of the system.

4.11 Environmental Plans, Permitting and Assessment

LSST has a detailed Site Environmental and Cultural plan (LPM-52) that defines how LSST will comply with all environmental and cultural regulations applicable to its development sites. Governing statutes and permit procedures will be adhered to for all construction and site occupancy efforts associated with the project. This plan briefly defines how these considerations will be folded into the project development and outlines a methodology that will be applied to all efforts directly and indirectly pursued for the LSST.

The LSST Observatory site is El Peñón peak on the Cerro Pachón ridge in Northern Chile. El Peñón is located 400 km north of Santiago and 57 km southeast of La Serena on property owned by AURA). The LSST shares the Cerro Pachón ridge with two companion observatories currently in operation — the 8.2m Gemini South and 4.1m SOAR telescopes. The Base Facility for LSST operations in Chile will be located in La Serena within the AURA-owned and operated compound.

A preliminary geotechnical site investigation of the El Peñón site was undertaken to validate the foundation assumptions and to provide data for the excavation planning. Borings were performed including recovery of rocks and lab testing of samples. No major fractures or discontinuities were found at the telescope location and a high bearing capacity was measured, indicating very favorable rock with high stiffness conditions similar to the Gemini and SOAR sites (IDIEM, 2007 and ARCADIS, 2009).

The comprehensive process of environmental/cultural analysis and permitting has been undertaken and completed. It began with the submittal of a Declaration of Environmental Impact (Document-5880) in July 2008 to the CONAMA, the Chilean agency similar to the US Environmental Protection Agency. After a series of reviews and public meetings, the LSST summit facility project was declared positively qualified in December 2008, and all building and use permits were authorized. Pursuant to Executive Order 12114 pertaining to environmental impact of federal projects extra-territorial to the United States, the procedures undertaken by LSST in Chile were reviewed and approved by the NSF in October 2010. LSST continues to pursue the environmental impact mitigations and specifically reports to the NSF on progress. The detailed plans and results are assembled in the LSST document archive in Collection-1545.

Management of Cerro Pachón and neighboring Cerro Tololo is provided by AURA under contract to the NSF. AURA has the procedures in place to accommodate tenant telescope organizations and maintains the necessary agreements with the government of Chile. Through agreements in place with AURA, as authorized by Chilean legislation, LSST will enjoy official international organization status with tax and duty exemptions. As described in Section 3.2, AURA has also established the necessary agreements with Chilean authorities that specifically address how Chilean Astronomy will benefit from LSST in-lieu of the normally granted 10% observing time, which is not appropriate for this dedicated survey facility.

5 Project Administration

The LSST project has a complete and comprehensive set of administrative policies and procedures that are defined in LPM-97 and a set of referenced documents. See Figure 4-1 for the full list of subordinate policy documents. These policies are consistent with AURA policies and procedures, NSF terms and conditions, federal cost principles, and LSST Corporation policies. The LSST Project Administration Policies manual defines the Project Office approach to human resource management, financial accounting, travel, communications and much more. It also defines the hierarchy and precedence for the references to the multiple organizational procedures should there be a conflict.

The LSST Camera Project follows SLAC and DOE policies and procedures. The LSST Director has a joint appointment with both AURA and Stanford and follows the procedure appropriate to each issue, the funding implications, and the AURA / SLAC MOU previously described in Section 3.1.

The following subsections focus on the Administration of the NSF and LSSTC funded elements of the LSST Project.

5.1 Human Resources

As outlined in LPM-97, the LSST project office follows all AURA personnel policies and procedures. The central AURA Human Resources department is utilized for all labor, benefit, and staff issues. All LSST Project Office employees, including the NOAO-based telescope and site team and Chilean staff, are AURA employees supported by the AURA HR department. All HR effort is supported through the AURA HR indirect rates defined in the Cost Estimating Plan (LPM-81).

The LSST Project Office is a single purpose organization and thus has no people or functions that are indirectly funded. All staff members charge directly to accounts specifically established for the work being performed.

The LSST Project has contributors at many other organizations as defined in Section 3.1. Their efforts are fully accounted in the PMCS, and the Bases of Estimates are in hours of work. All non-AURA effort is funded through contracts with organizations. These contracts are primarily for specific product deliverables, but even if contract terms are "time and material" base, each of these organizations is responsible for their respective Human Resource management as defined by their policies and the contractual terms and conditions established with the LSST Project Office.

LSST PO follows the AURA benefit package and works with the HR department to establish compensation packages that are reasonable and consistent with industry and government standards while recognizing that many positions are term appointments for periods up to the duration of the LSST Project. The LSST project is focused on the design, construction, and commissioning of the system, but scientists play key roles in many of the functional efforts. LSST provides LSST scientists the ability to spend 20% of their time to pursue personal science activities related to LSST. There are conditions applied to this benefit as further described in the Project Administration Policy and the Cost Estimating Plan (CEP), which provides an explanation for booking 1800 hours of time per year for engineering and administrative staff and 1440 hours for scientist's time in the PMCS.

The LSST Project Office follows the guidance provided by OMB Circular – 122 (NARA, 2012) regarding compensation for authorized absences. As authorized absence benefits are accrued, the funding is debited in proportion to the work performed. Accrual as earned allows proper allocation and ensures there are no unfunded liabilities.

5.2 Accounting

LSST follows all Generally Accepted Accounting Principles (GAAP), Financial Accounting Standards Board (FASB) Statement of Financial Accounting Concepts, and OMB Circulars A-110, A-122, and A-133, and complies with all statutory and regulatory requirements. LSST also adheres to the AURA Financial Policies and Procedures, which are designed to ensure compliance. The Business Manager maintains expertise in the cost principles set forth in OMB Circular A-122 including its revisions or superseding documents.

As a recipient of government funds, LSST is subject to audit by federal agencies in addition to its outside independent auditors. As described in Section 4.1, the LSST PMCS system is integrated with the AURA accounting system in such a way as to support EVMS and to provide timely reports of variances with respect to the baseline project plan. Detailed Financial, Accounting, and Ethics Polices may be found online on AURA's website.

5.3 Basis of estimate for budget components

The Cost Estimating Plan (LPM-81) and the Project Controls Management Plan (LPM-98) define the guidelines and methodology used to prepare and maintain the task-based cost estimate for the LSST Project. This guidance is provided to assure that the final product is complete, consistent, and well documented.

For the task-based estimate, formal procedures are used to define tasks and assign them to the lowest-level elements of the WBS. The entire ensemble of tasks represents all the required resources, activities, and components of the entire project. Each of the tasks is scheduled and estimated by the teams using accepted techniques. The estimates are documented with a Basis of Estimate (BOE). Cost-estimate data is prepared by cost estimators in any of several possible forms (work plans, Excel worksheet template, a text document, etc.) so long as the form is agreed upon in advance and meets the objectives. To facilitate proper integration into the LSST project control system, standard Primavera layouts are used to enter the information into the database.

Each item in the cost estimate is tagged with a descriptor that characterizes the estimated quantity or cost. The categories established for the project include: historical data (HD), catalog prices (CP), vendor quotes (VQ), vendor estimates (VE), vendor contract (VC), engineering estimates (EE), or cost estimating relationship (CR). Specific identification of the category of each item in the estimate enables costs to be sorted by category for analysis.

Each detailed task-based cost estimate corresponds to a task in the project schedule. For that specific task, resources and their quantities are assigned from a standardized list of resources. The list includes multiple resource classes in each of the categories: labor, materials/non-labor, or travel. A task estimate consists of the number of hours of each labor resource class, the base-year dollar cost of each materials/non-labor resource class, the number of trips for each travel resource class, and the basis for each estimate.

Cost reports are distributed and discussed with the cost estimator for verification of the accuracy of the appropriate estimates. The estimator is also responsible for providing copies of supporting information for inclusion in the BOE. The base-year for the estimates and each basis of estimate were refreshed prior to the NSF Preliminary Design Review and will be again refreshed for the Final Design Review and other major project milestones as directed by the NSF. The Project Office expects to have estimates that are less than 6 months old for any major review of the project or detailed audit.

5.4 Project Communications

The LSST Project Office Communication Handbook (LPM-82) describes the policies, tools, processes, and procedures used by the project office to communicate both internally within the project team and externally with stakeholders, the public, and the scientific community. The goal of the communications policy is two-fold: 1) to provide timely, accurate, clear and complete information about LSST's policies, procedures, decision, tools, and actions; and 2) to facilitate communications within a distributed project.

To facilitate internal communications, the project office maintains numerous teleconference numbers which are available 24/7; each is capable of handling up to 50 participants. There are multiple, weekly video and/or teleconference meetings to address both scientific and engineering issues within the project. LSST has Web Based "GotoMeeting" Accounts and the Camera team has access to "Readitalk". The project also hosts wikis for use by groups within the project to communicate and work collaboratively.

The project also maintains two Web sites: www.lsst.org for public access and www.lsstcorp.org for password-protected project materials. A Web-accessible archive center (built on Xerox's DocuShare) already contains thousands of entries on the latter site.

Schedules for all regular meetings and telecons are maintained on the project calendar at www.lsstcorp.org. The Review Hub (https://www.lsstcorp.org/reviews/hub/) serves as a clearinghouse for information about external reviews, meetings, and workshops planned across all elements of the LSST Project.

All media inquiries are referred to the LSST Communications Officer, who is responsible for determining the appropriate response, with appropriate consultation with the Project Director and/or Project Manager. Before issuance, press releases are vetted with the appropriate NSF and DOE program officers. LSST E-News is published quarterly and reports news, programmatic and technical updates, and other notable items to project personnel, science collaboration members, and the interested public.

5.5 Community Interactions

The primary vehicle for community interaction with the LSST Project Office during the construction phase will be the Science Advisory Committee (SAC). The SAC will provide advice to the Director on both technical and policy issues of interest to the broad astronomy and physics communities. It will meet monthly by teleconference and twice per year in person. The membership of the SAC will be comprised of LSST-related scientific collaborations and other experts covering the diverse fields of LSST-science. There will be two elected representatives of the Chilean LSST community who will also serve on this committee. Minutes of the SAC meetings will be made publicly available on the LSST website.

The LSSTC Board of Directors will also provide oversight of the project with respect to science and policy issues. The Director will report monthly to the Board by teleconference. The members of the Board of Directors are elected by the LSSTC member institutions.

The LSST Project Office will further solicit input from the community at key scientific and technical conferences, such as those held by the American Astronomical Society, the American Physical Society, and the Society of Photo-optical Instrumentation Engineers. In addition, the Project Office will publish a monthly newsletter highlighting major events and accomplishments to keep the community well-apprised of the progress in construction and commissioning.

6 Project Baseline

The LSST Project Office maintains the technical, cost, and schedule baselines for the project. The technical baseline is managed as defined in the Systems Engineering Management Plan (LSE-17) and the Change Control Process (LPM-19). The project will report status and actuals relative to the schedule and cost baseline as defined in the PMCS Management plan.

During the Design and Development effort, the schedule and cost baseline were published in incremental updates associated with major reviews or key changes as directed by the Federal Agencies. Each published baseline update is maintained on a dedicated website (https://www.lsstcorp.org/costreview/2013/home) that includes the LSST comparison tool that allows changes in labor hours and costs to be directly compared down to level 3 in the WBS. Each update includes full cost books, summary charts and, after the Final Design Review, the revised baselines will include a full list of change requests that will describe the incremental updates between baseline revisions. All changes to the baseline will be made within the authority limits and reporting requirements established by the NSF, and no changes will affect the total project cost or schedule without coordination with the NSF program officer and cognizant contract officer.

At the beginning of the construction phase, and as requested by the NSF, the Project cost and schedule baseline will be updated in FastLane as well. During construction, earned value reporting will be provided on a monthly basis as defined in the Project Controls Management Plan (LPM-98). These reports will include the interim updates to the baseline as minor adjustments are made in coordination with the NSF Program Officer.

6.1 Project budget by WBS element

The total budget request to NSF is $488.4Min then-year USD with contingency. The project budget by WBS element is part of the project cost book; it is available as a roll-up in LSST document LPM-46. The cost detail report is available as LSST document LPM-45. The budget breakdown by WBS is not listed here as it is subject to frequent, minor updates. Please reference LPM-45 and LPM-46.

6.2 Project schedule

Figure 6-1 presents an overview of the integrated LSST construction schedule, including key project milestones. The proposed start for both MREFC and DOE MIE funding is Fiscal Year 2014. MREFC construction and commissioning starts July 1, 2014 and will require 99 months, which includes schedule float (schedule contingency) on the key elements of the system as listed in Figure 6-2. With a July, 2014 MREFC start, engineering first light will occur with a single raft commissioning camera no later than October 2019; the actual date will depend on how much of the schedule contingency is used. The commissioning period is integrated into the schedule as major subsystem elements become available and will require 18 months from the delivery of the completed LSST Camera to Cerro Pachón for integration onto the telescope; full-scale science operations will begin no later than Oct 2022.

Subsystem Element	**Float in Months** (per Schedule at FDR)
Data Management Subsystem	12
Camera Subsystem (Sensors)	7
Camera Subsystem (L1-L2 Optics)	13
Telescope Subsystem	11
Education And Public Outreach Subsystem	12
Commissioning	11

Figure 6-1: Schedule Float (schedule contingency) on Key Elements of the LSST System

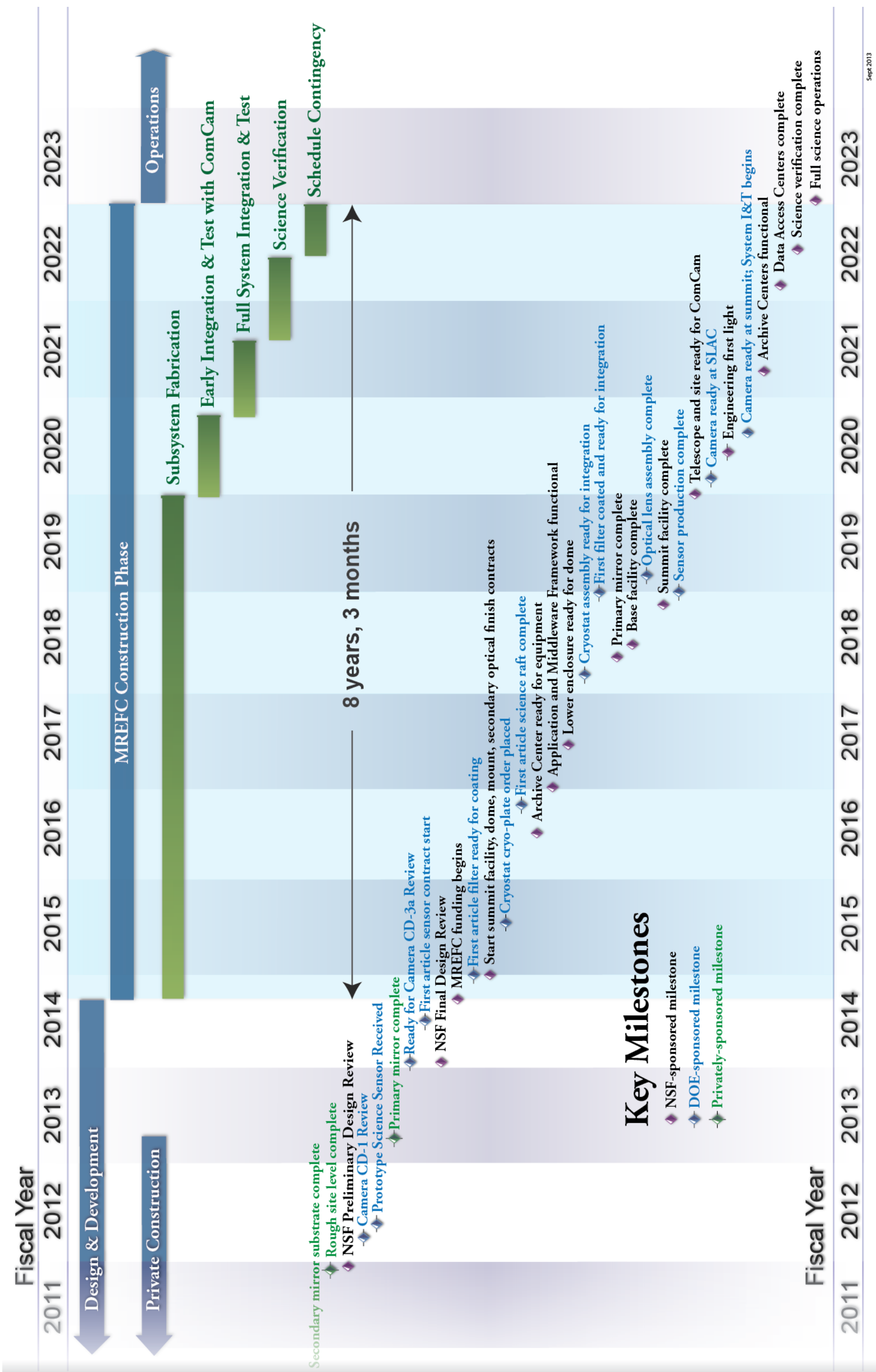

Figure 6-2: Integrated LSST Construction Schedule Including Key Project Milestones.

Full construction of the LSST in 99 months is made possible by privately funded early construction activities already in progress. Fabrication of the primary/tertiary mirror, acquisition of the secondary mirror blank, summit site preparation, and prototyping of the CCD sensors have been supported by private funding. These long-lead activities, with a total budget of about $40M, started in 2005 and will be completed well before the time needed to support the schedule shown in Figure 6-1.

6.3 Commissioning Plan; System I&T and Performance Verification

The LSST Commissioning Plan (LSE-79) describes the full set of activities for commissioning the LSST observatory facilities in Chile and the partial commissioning of the archive facility at NCSA. It covers initial commissioning of the annual data release processing pipelines and data products production sufficient to start operations; the final commissioning of these elements is necessarily covered under Operations with full survey data. The plan outlines the early commissioning work with a commissioning camera, technical integration activities and tests that must be accomplished with the science Camera during the System Integration and Test period, the verification methods that will be used to show compliance with the survey performance detailed in the SRD (LPM-17) and the LSST System Requirements (LSR, LSE-29), the specific tests, measurements, and analysis that will be done to show compliance with the SRD, the overall management structure, lines of authority, oversight, and data distribution policies that will be in place for the commissioning period, and the criteria, methods, and review processes that establish the readiness of the LSST for operations.

Project level commissioning activities are led by the LSST Systems Engineering Team and occur over three phases of effort. The SE team does preliminary commissioning work when subsystems are conducting their tests and verification but the formal effort begins with the installation of a one-raft commissioning camera (ComCam) onto the telescope. This early commissioning will be 6-months and will accomplish full Telescope commissioning, significant DM algorithm and infrastructure commissioning and partial Camera interface commissioning. The second phase is 9 months for the installation of the full Camera and the associated system integration, test, and verification. With the LSST fully functional, the final phase of commissioning work is another 9 months of science verification which concludes with an operational readiness review followed by full survey operations.

This first phase of commissioning is achieved with ComCam, a joint effort of the Camera and Telescope subsystem teams. ComCam is a cooled Dewar with a single production quality raft populated with 9 grade B sensors, a corrector lens set, a manual filter slot, and appropriate on-telescope fixtures and utilities to provide performance comparable to the full Camera at a one raft size. A DM cluster with 10% of the final designed capacity will be delivered and in place to support ComCam use in this phase. ComCam will be installed when the Telescope team has completed its' initial integration and verification steps and is ready for joint commissioning work with the SE team. ComCam will provide data to DM sufficient for an additional level of software debugging above that achievable with simulated and other existing data. The initial commissioning work with ComCam will include LSST "Engineering First Light", where the telescope has demonstrated SRD-like image quality over 40 arcmin, Camera and Telescope under OCS scheduler control, and data processed using initial Data Management pipelines. "Engineering First Light" occurs approximately 66 to 72 months after the start of MREFC funding depending on how much of the schedule contingency is used and the detailed planning for the early commissioning efforts.

The full system commissioning period of the project is completed in phases 2 and 3. Phase 2 is system

Integration and Test (I&T) and begins when the full Camera is on site ready for integration onto the telescope. This system I&T is a 9-month effort to complete the technical integration of the three subsystems focused on the Camera and finalizing efforts with the Telescope and DM to show compliance with system level requirements detailed in the Observatory System Specifications (OSS) (LSE-30) and Interface Control Documents.

The final phase of commissioning, Phase 3, is Science Verification. This 9-month phase is designed to show compliance with the survey performance specifications detailed in the SRD. These activities are based solely on the measured "On-Sky" performance of the LSST system. The data from these activities may be released for analysis and early scientific studies but priority will be given to completing the necessary validation tests.

Science Verification will be structured in a succession of activities focused on particular capabilities:

- Verifying compliance with single visit performance requirements
- Verification of the full survey performance requirements for image stacks and area coverage
- Final science verification and acceptance tests for operation readiness.

The schedule includes time for engineering related activities throughout, with more engineering time planned at the beginning and transitioning to something near early operational levels by the end.

During the Commissioning phase it is important that a balance is maintained between obtaining on-sky astronomical data needed for science verification and allowing extended periods for technical work. Built into the scoping of each on-sky commissioning activity is roughly a 50/50 duty cycle between obtaining astronomical data and technical work. Intervals dedicated solely to engineering and technical work are scheduled at the end of Early System Integration & Test and at the end of Science Verification. This dedicated engineering time will allow uninterrupted work to address critical issues. The first scheduled engineering block is 30 days long and follows the Camera-Telescope integration. The second 60-day period comes at the end of the science verification phase following the final 30-day mini-survey.

Throughout the construction phase of the project, the three technical teams from the Telescope & Site, Camera, and Data Management subsystems will have been operating nearly independently of each other, except where critical interfaces require close interaction between teams. During commissioning phases 2 and 3, after Engineering First Light, the three technical teams will be merged into the Commissioning team. This single technical team shall take direction for day-to-day activities from the Project Systems Engineering office. The Project Systems Engineer and Systems Scientist will be responsible for prioritizing the commissioning activities to ensure that the deliverables are met. The Project Manager will hold overall authority over all commissioning activities, schedule, and budget.

In addition to the technical team, the Project will add a dedicated team of scientists and analysts whose purpose will be to evaluate the science quality of the commissioning data and provide feedback to the technical team. The science quality assessment will be based primarily on demonstrating that the SRD performance requirements are being met and extending this analysis to "user level" science programs.

The final survey verification phase will consist of a 30-day continuous mini survey to demonstrate readiness for full LSST science operations. This survey will be under full autonomous scheduler driven operation. Thirty days of survey operations is sufficient to cover the daily operational efforts of maintenance and calibration and the operational cycle over a full lunation, including the u-band filter swap over dark time. Assuming the typical usable weather fraction, the 30-day mini survey will yield approximately 20,000 visits sufficient to provide multi-epoch coverage of the sky in 2-3 filters or a single epoch with all 6 filters (see A.2 example mini-survey #1). The data from this effort will be treated as if it were part of normal survey operations and will be an early release data product for the community.

An Operations Readiness Review (ORR) will be held jointly by the Project and the federal funding agencies as a means to formally close the MREFC construction project and initiate full survey operations. At the ORR the project will present the following:

- Documented analysis showing compliance with the performance specifications called out in Section 3 of the SRD;
- Successful completion of the 30-day mini-survey showing that the LSST Observatory can sustain operational status over the critical cycle of one full lunation.
- Analysis of the 30-day mini-survey that shows extrapolated performance that meets the 10-year survey specifications;
- The ability of the LSST Observatory to monitor and assess the progress of the survey towards its 10-year specifications;
- Operational procedures developed during the Commissioning period, which have been documented and are shown to comply with the LSST Safety Policy (LPM-18);
- A prioritized “punch” list of outstanding technical issues that will need to be addressed during the early stages of operations.

6.4 Plans for Transitioning to Operational Status

The goal of the transition to operations is to take advantage of the skills and knowledge developed during construction and commissioning to ensure a rapid and efficient start of operations. A key element to this will be an early operations phase where the Operations Team can build up and gain experience shadowing the Construction and Commissioning Teams. The construction plan includes all the necessary recourses to complete the activities and deliverables for the LSST Project but an early operations team can begin detailed planning while observing integration and verification activities. The Construction Project Team will coordinate with the Early Operations Team to hand over completed elements of the system so smooth transition can happen at every level of the project. An example would be the EPO system. When the LSST Construction Project completes the EPO hardware deliverables, the Operation team will want to transition key staff to have continuity. Another key element to the early operations effort is to have strong advocates for operations interests as the Construction Project completes work and holds final operational reviews.

The Project will hold an Operations Review in April 2016 to present the plans for Operations and the transition effort. This review will focus on the technical details of operations, the schedule, and the management plan. The Review is scheduled in time to inform a formal proposal led by AURA on behalf of effort that includes SLAC, and LSSTC.

Planning for the transition from construction to operations and for steady state operations can be found in LPM-73. Preliminary estimates are that steady-state operations will require a permanent staff of approximately 140 people; approximately 60% of this staff could be filled by commissioning personnel if they choose to continue into operations. The remainder will be new hires at all three LSST locations: Tucson headquarters, Chile, and NCSA. In order to manage this increase in staff smoothly and ensure adequate training prior to the start of full survey operations, a gradual ramp-up toward operations will be proposed in the Early Operations activities. This operations staff will be able to undertake such tasks as: 1) Preparation of documentation, sponsoring workshops, and training the community in how to use LSST data products: 2) using the alerts delivered by the commissioning camera to begin working with brokers on the classification of sources; 3) accept and assume responsibility for the operation and maintenance of the calibration telescope; 4) initiate EPO operations because construction of the EPO facility will be complete several months prior to the start of full survey; 5) take over maintenance of such auxiliary equipment as the weather stations, DIMM, and all sky camera; and 6) maintain the base facility in La Serena. See LPM-73 for more details.

6.5 LSST Steady State Operations Plan

The LSST Observatory has two interrelated objectives: (1) enabling key science through the conduct of the multi-epoch, all-sky survey over a 10-year period and (2) making an unprecedented volume of data and derived metadata accessible and usable by its intended communities. This two-fold mission distinguishes LSST operations—and LSST operations planning—from traditional observatories. In addition to achieving the operational effectiveness and performance of the telescope, the LSST mission requires effective management of a complex data processing, delivery, and archiving system, including multiple operating facilities at multiple distributed sites. The size of the sample of objects is also unprecedented (tens of billions), leading to the need for a qualitatively different level of control of data quality than normal for observatories.

An estimate of the annual operating costs has been made based on bottoms-up estimates of equipment and personnel needed to perform all the tasks required during operations. A use case methodology was adopted in order to identify the necessary tasks and types of expertise needed to carry out the entire range of LSST functions. These estimates were then compared with operational data from current large telescope projects and large surveys and from data supplied by data centers and network providers. The total costs of operation are estimated to be $40M ($US 2013), and the total staff at all locations is 140, including seven of the people who are subcontracted to develop software during construction to carry out maintenance and upgrades during operations. Also included in this total are an estimated 14 people based in the community, who will be hired on a temporary basis for specific tasks related to upgrades to the software systems (i.e., improved algorithms and Level 3 data products) and quality assessment related to specific scientific programs. In addition, SLAC is planning to provide three FTE to perform major camera maintenance that cannot be carried out by on site personnel.

More details about the current estimates of the operating costs can be found in LPM-73.

6.6 Decommissioning Plan

The LSST Project is committed to building a system that can be operated efficiently to meet the scientific requirements for the planned 10-year survey. The facilities are being designed to have a 50-year lifetime, and it is likely that the LSST will continue to make important scientific contributions after completion of the 10-year survey. It would be appropriate for the NSF to conduct a review of the LSST progress and facilities after about 5 years of operation to determine whether it is desirable to continue facility operations, perhaps with different instrumentation, when the full 10-year survey is completed.

We have, however, developed the LSST Decommissioning Plan (LPM-71), which addresses the ultimate disposition of LSST assets at the conclusion of the useful life of the facilities or when the cost / benefit for continued operation no longer satisfies NSF and DOE sponsorship. Several approaches can be considered to responsibly terminate LSST operation, including establishing a minimal maintenance state, transferring responsibility, or removing the infrastructure entirely.

The Decommissioning plan provides the programmatic plan and technical options to be undertaken to define and execute the final termination of the LSST. The plan addresses each of the LSST facilities, hardware, and instrumentation that are distributed in Chile and the United States. The options for the final decommissioning of these assets vary by function and location so each is addressed separately.

The purpose of the decommissioning phase is to efficiently and safely terminate operations and transition the LSST from full operations to its minimal state. The curation of data is an important issue for defining the LSST minimum state. This aspect of decommissioning is addressed primarily through the LSST Data Management Plan.

7 Project Technical and Financial Status (Sept 2013)

The LSST project is currently in the Design and Development (D&D) phase and will be ready for a construction start in FY 2014. The LSST design is mature with hardware and software plans in place that directly support the Science objectives for the System. The Science Requirements (LPM-17) are stable and have been used to develop a full set of requirements for the separate subsystems. Designs are established, software frameworks are in place, prototypes have been built and tested, and the risks for the remaining development and construction are fully established and consistent with the risk adjusted budget presented to the two agencies. The Camera team is ready for an MIE new start authorization and the rest of the Project is ready for an MREFC new start in FY2014.

The Project office is established with 16 of the 20 key staff positions identified in Figure 3-1 already in place and all policy, procedures, and tools in place for a successful single integrated LSST Project. The Director for construction took office in July 2013 taking on the new role after more than a decade with the Project. His joint appointment described in Section 3 positions the single Director to be responsible to both agencies for the successful LSST Program. The Project Manager is in place and has established his responsibilities and authorities for the integrated project while operating within the two-agency framework. Each of the policies identified in Figure 4-1 are in place and under Configuration Control. The team has been functioning together for many years and the communication and coordination tools and approach are established and proven. The Integrated Project Schedule has been under development with the rest of the project and has been through several revisions to synchronize the subsystem plans. The two most recent revisions involved synchronization of the NSF and DOE schedules after updated funding profiles were provided by the two respective agencies.

Each LSST Subsystem is at the level of maturity commensurate with its construction approach. The Data Management Team has successfully executed 8 data challenges and 8 full software data releases, establishing the framework for the software, the database design, and hardware architecture through formal models and performance tests. The team is distributed but institutional roles are established, and the team is experienced in working as a group toward LSST development. The Telescope Team has completed the critical designs for the system focusing on establishing design/build contracts for testable subsystems. They have successfully completed over $25M in fabrication and construction efforts (non-federally funded) and have two major contracts in place with two more procurements started. The four together will represent roughly $70M in fixed price contract efforts, a significant budget risk mitigation and demonstration of team performance. The EPO group has established the full scope and requirements for the system and has completed a logic models and prototype community interfaces to develop the tools to maximize educational interaction with the LSST Data set. The Camera team is creating detailed designs for the system, has completed numerous simulations and hardware prototypes, and has initiated the procurements of the two key elements of the system: the sensors and the L1-L2 assembly. The Camera team is working successfully as a broad collaboration within the DOE system having completed many agency reviews. The schedule for Critical Decision 2 (CD-2) is being revised but long lead procurement authorization is planned earlier with CD-3a in February 2014.

LSST Systems engineering has the full requirements documentation in place as well as the verification plans. All Interface Control Documents (ICDs) between the subsystems have been established and all are at the appropriate level of completion. Fifteen of eighteen ICD's are in Phase 2 Development or beyond, allowing all subsystems to progress with detailed design effects.

The fiscal status of the LSST Project is consistent with the NSF Design and Development plans and the DOE Research and Development plans. LSST has a 3-year cooperative agreement in place with the NSF for 2012 – 2015. This effort is proceeding according to the plans established in that proposal. With a 2014 MREFC new start, this NSF CA can be cancelled. The Project provided detailed plans for the third year of the cooperative agreement if the MREFC program does not start in 2014 as planned. The Camera team and SLAC are continuing to work with the DOE to address the highest risk elements of the design as part of a comprehensive development plan that is funding limited. All project efforts are reported to the agencies for technical and financial status.

Appendix A: Project Execution Topics cross reference

NSF Project Execution Plan Topics	LSST Project Execution Plan	Additional LSST References
Description (Desc.) Of research objectives motivating the facility proposal	Section 2.1	
Comprehensive statement of science requirements, to be fulfilled by the proposed facility	Section 2.2	SRD LPM-17
Desc. Of Edu. Outreach & Broader Societal Impacts associated with purpose of facility, including scope of work, budget & schedule	Section 2.4	
Desc. Of infrastructure necessary to obtain the research and education objectives	Section 2.3	
Work breakdown structure (WBS)	Section 4.2	LPM-43
WBS dictionary defining scope of WBS elements		LPM-44
Project Budget, by WBS element	Section 6.1	LPM-45 LPM-46 Cost Baseline web page
Desc. Of the basis of estimate for budget components	Section 5.3	LPM-46 LPM-81
Project risk analysis & desc. analysis methodology	Section 4.3	LPM-20 LSST Risk tool page
Contingency budget & desc. Of method for calculating contingency	Section 4.4	LPM-61
Project schedule (and eventually a resource-loaded schedule)	Section 6	Cost Baseline web page
Organizational Structure	Section 3.3	
Plans & commitments for interagency & Intl. partnerships	Section 3.1 and 3.2 Section 6.5	

Acquisition plans, sub-awards & subcontracting strategy	Section 4.12	LPM-74
Project technical & financial status reporting, function of PMCS, & desc. Of financial & business controls	Section 4.1 Section 5.2	LPM-98 LPM-81
Project governance	Section 3.1	
Configuration control plans	Section 4.6 Section 4.8	LPM-19
Contingency management	Section 4.4	LPM-61
Internal & institutional oversight plans, advisory committees, plans for bldg. & maintaining effective relationships w/ broader research community	Section 3.3 Section 3.5 Section 5.5	
Quality control & QA plans	Section 4.7	LPM-55 LSE-63
Environmental plans, permitting & assessment	Section 4.11	LPM-52
Safety & health issues	Section 4.5	LPM-18
Systems Engineering Requirements	Section 4.6	LSE-17
Systems integration, testing, acceptance, commissioning & operational readiness criteria	Section 6.3	LSE-79
Plans for transitioning to operational status	Section 6.4	
Estimates of operational cost for the facility	Section 6.5	LPM-73

References

Project Documents and Tools

- Cooperative Support Agreement (CSA) AST-1227061 (Document-14949)
- Declaration of Environmental Impact (Document-5880)
- LSST Camera Auxiliary Units and Overage Plan (LCA-398)
- LSST Camera Project Execution Plan (LCA-225)
- LSST Camera Project Management Plan (LCA-226)
- LSST Change Control Board Workflow (https://www.lsstcorp.org/groups/ccb)
- LSST Change Control Process (LPM-19)
- LSST Commissioning Plan (LSE-79)
- LSST Cost Baseline (https://www.lsstcorp.org/costreview/2013/home)
- LSST Cost Estimating Plan (LPM-81)
- LSST Decommissioning Plan (LPM-71)
- LSST Document Management Plan (LPM-51)
- LSST Hazard Analysis Plan (LPM-49)
- LSST Observatory System Specifications (LSE-30)
- LSST Operations Plan (LPM-73)
- LSST Organization and Staffing (LPM-103)
- LSST Project Controls Management Plan (LPM-98)
- LSST Policies and Procedures Manual (LPM-97)
- LSST Project Office Communications Handbook (LPM-82)
- LSST Project Quality Assurance Plan (LPM-55)
- LSST Risk Management Plan (LPM-20)
- LSST Risk Management Tool (https://www.lsstcorp.org/riskmanagement_index.php)
- LSST Safety Policy (LPM-18)
- LSST Science Requirements Document (LPM-17)
- LSST Site Environmental and Cultural plan (LPM-52)
- LSST Succession Plan (LPM-84)
- LSST Systems Engineering Management Plan (LSE-17)
- LSST System Requirements (LSE-29)
- LSSTC Institutional Membership Policy (LSSTC-12)
- LSST Technical Baseline Classified Index (LSE-90)
- LSST Technical Scoping Options (LPM-72)
- LSST WBS Cost Details by Activity (LPM-45)
- LSST WBS Cost Summary (LPM-46)
- LSST WBS Dictionary (LPM-44)
- LSST Work Breakdown Structure (LPM-43)
- LSSTC Board Meeting Minutes – April 2013 (Document-14670)
- LSSTC Institutional Membership Application Policy (LSSTC-12)
- Management of LSST: A Partnership between AURA and LSSTC (Document-13153)

- Memorandum of Agreement between Board of Trustees of the University of Illinois and AURA (Document-4245)
- Memorandum of Understanding between Caltech and LSST (Document-4581)
- Memorandum of Understanding between CNRS and LSST (Document-14953)
- Memorandum of Understanding between LSST Corporation and AURA (Document-11647)
- Memorandum of Understanding between LSST Project Office and NOAO (Document-13848)
- Memorandum of Understanding between NSF and DOE Concerning Cooperation on the LSST (Document-13847)
- Memorandum of Understanding between the Regents of the University of California and LSSTC (Document-3555)
- Memorandum of Understanding between SLAC and AURA (Document-11515)
- MREFC Construction Proposal for LSST (Document-10548) Site Selection Committee Final Recommendation Report (Document-1796)
- Supplementary and Clarifying Agreement between the Universidad de Chile and AURA Covering the Use of LSST on Cerro Pachón (Document-11622)

External Documents

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- AURA. (1996). “AURA By-Laws”, Available from http://www.aura-astronomy.org/about/sectionD.asp.
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