LARGE SYNOPTIC SURVEY TELESCOPE

Large Synoptic Survey Telescope (LSST)

EPO Design

LEP-31

Latest Revision Date: Aug 18, 2017

Change Record

Version	Date	Description	Owner name
2.0	10/7/2013	FDR version of EPO Baseline Design, D-12079	S. Jacoby
3.0	10/2016	Refreshed based on updated EPO Requirements (LSE-89) and planning subsequent to FDR	B. Emmons
3.1	10/26/2016	Replaced full text of LSE-29 and LSE-30 requirements with a reference.	B. Selvy
3.2	10/28/2016	Removed telescope status reference since Engineering Facilities Database (EFD) status is in flux	B. Emmons
3.3	10/28/2016	Added support section	B. Emmons
3.4	11/1/2016	Updated Operational Readiness appendix	B. Emmons
3.5	11/18/2016	Updated primary authorship to include S. Jacoby for proper attribution	B. Emmons
3.6	11/22/2016	Added light curve plot feature to Object Pages section	B. Emmons
4.0	07/18/2017	Refreshed based on Operations planning	A. Bauer, B. Emmons, E. Bechtol
4.1	07/25/2017	Reorganized Section 4 and added intro text to several sections	A. Bauer
4.2	07/26/2017	Updated the EDC derivative data sources	B. Emmons
4.3	08/02/2017	Added evaluation information for each initiative and revised evaluation sections	E. Bechtol
4.4	08/03/2017	Reorganization and content edit	A. Bauer
4.5	08/09/2017	Formatting	B. Emmons
4.6	08/18/2017	Scope verbiage from recent long-range EPO planning	A. Bauer, B. Emmons

Table of Contents

Change Record 1
Executive Summary 3
1 Requirements 5
2 Responsibilities 6
3 EPO Program Initiatives 7
EPO Portal 7
Formal Education and Data Access 9
Citizen Science 11
Multimedia for Planetariums and Science Centers 12
4 EPO Data Center 14
5 Evaluation 17
6 Staffing 20
7 Appendix 21
Operational Readiness 21

Executive Summary

This document provides an overview of the Education and Public Outreach (EPO) program for the Large Synoptic Survey Telescope (LSST). It defines the specific EPO program elements that shape the costs, schedule, and scope detailed in the LSST Project Management Control System (PMCS) - WBS 5.0.

The purpose of LSST EPO is to provide non-specialists access to LSST data through tools and interfaces that engage diverse communities with authentic research experiences and activities. Key responsibilities are guided by requirements for user-centered learning experiences that meet the needs of specific audiences with different levels of knowledge, experiences, and skills.

LSST EPO will serve four main categories of users: 1) general public, 2) formal educators, 3) citizen science principal investigators, and 4) content developers at informal science education facilities. These audiences will be reached through four initiatives of the EPO program: the EPO Portal, formal education and data access, citizen science, and multimedia.

A goal of LSST EPO is to facilitate a pathway from entry-level exploration of astronomical imagery to more sophisticated interaction with LSST data using tools similar to what professional astronomers use for their work. The EPO Portal will enable members of the public to explore color images of the full LSST sky, examine objects in more detail, view events from the nightly alert stream, and investigate scientific questions that excite them using real LSST data in digital science notebooks.

Formal educators will have access to online, easily adoptable classroom investigations designed to support key aspects of the Next-Generation Science Standards (NGSS)[1] in the USA, and goals of the Explora program[2] through CONICYT in Chile. LSST EPO's Education Team will also provide the professional development training and instructional materials necessary to help educators successfully engage their students with these online data investigations.

Anyone around the world will be able to participate in a large variety of citizen science projects that use LSST data. The EPO Team will work with Zooniverse's Project Builder to develop tools compatible with LSST data, allowing LSST principal investigators to create any number of projects to help them accomplish their science goals. EPO anticipates that the number of citizen science projects in the astronomy field will increase dramatically when LSST is operational, giving a whole

[1] https://www.nextgenscience.org/

[2] http://www.explora.cl/

new generation of citizen scientists the opportunity to deepen their engagement with astronomy using real data from LSST.

LSST EPO will provide multimedia visualizations for use by museums, science centers, and planetariums around the world, offering maximum flexibility in adapting the materials to specific needs. These visualizations, associated metadata, and distribution methods will follow industry standards and best practices.

Underlying all EPO programing is critical infrastructure that responds quickly to varying levels of demand. Therefore, a foundational component of LSST EPO is the cloud-based EPO Data Center (EDC) which allows for scalable, on-demand computing best suited to the EPO audience.

Finally, where possible, LSST EPO products will be available in both English and Spanish, enabling wider access and participation (especially to our Chilean partners).

1 Requirements

At the highest level, the need for an EPO program is established in the LSST System Requirements Document (LSR, LSE-29) and flows down to the LSST Observatory System Specifications (OSS, LSE-30). From there, full implementation requirements are detailed in LSE-89 (EPO Subsystem Requirements) and LSE-131 (DM/EPO Interface, which includes details of the subset of LSST data to be transferred to the EPO Data Center). Details related to EPO Commissioning are included in LSE-79 (LSST Commissioning Plan) and details for EPO Operations are included in LPM-181 (LSST Operations Plan).

This technical system-level documentation is under Change Control within the LSST Project and the work within is subject to Compliance and Verification Procedures (LSE-160) as defined by the LSST Systems Engineering Team.

Reference Documents:

- LSST System Requirements (LSR) (LSE-29)
- Observatory System Specifications (OSS) (LSE-30)
- EPO Subsystem Requirements (LSE-89)
- DM/EPO ICD (LSE-131)
- LSST Commissioning Plan (LSE-79)
- LSST Operations Plan (LPM-181)

2 Responsibilities

The key responsibilities that drive the overall scope of LSST EPO are:

- Provide non-specialists access to LSST data through online tools and interfaces.
- Facilitate citizen science projects that use LSST data.
- Further STEM education and training by engaging with educators to integrate real LSST data into classrooms and introductory astronomy courses.
- Develop multi-media resources for content developers at informal science education facilities.
- Build partnerships with institutions and organizations serving under-represented groups in STEM and proactively engage with diverse audiences.
- Engage with the Chilean community by providing EPO products in Spanish.
- Remain agile and relevant during the full lifetime of LSST Operations by adjusting to technology trends and changes in educational priorities.
- Provide evidence-based evaluation of the LSST EPO program and publicly report findings.

To achieve these responsibilities, the LSST EPO team will engage with a variety of audiences and LSST partners to create powerful and easy-to-use digital tools for exploring a rich subset of LSST data, enabling users of any background to engage with the Universe like never before.

3 EPO Program Initiatives

To meet the needs of its different audiences, the EPO Program is organized into four initiatives. Each initiative is intended to provide a different primary audience with the appropriate tools and interfaces to engage with LSST data, and designed to achieve specific outcomes. This section describes the goals, responsibilities, and desired outcomes the four initiatives, which are the EPO Portal, formal education and data access, citizen science, and multimedia.

In addition, EPO will develop opportunities for Broader Impacts that members of the LSST Science Community can easily tie into:

1) Develop Jupyter modules,

2) Implement pre-cursor data into EDC,

3) Share networks (particularly with minority-serving institutions),

4) Expand EPO's network at strategic conferences/events,

5) Prototype citizen science projects with LSST data, and

6) Prototype EPO's professional development program.

EPO Portal

The LSST EPO user experience is centralized at the EPO Portal, the online connection to all initiatives described here. The EPO Portal will be mobile-friendly and available through a native app (with expanded capabilities, like GIS and gyroscope positional awareness). The EPO Portal features a homepage, Sky Viewer, Multimedia Gallery, the Education Hub, data access through Science Notebooks, citizen science projects that use LSST data, real-time telescope status, and contact and support information.

The Sky Viewer will allow users to pan and zoom around LSST Annual Data Release color co-add images, enhanced with LSST Alert Stream-powered overlays and curated objects of interest like visually interesting galaxies, the Magellanic Clouds, supernovae discoveries, etc. Users will be able to see limited information on all objects shown in the Data Release images, and will be able to click through to informative Object Pages for those objects included within the EPO Data Center (details of the subset of LSST data to be transferred to the EPO Data Center can be found in LSE-131). Object Pages will contain available images, metadata, basic graphs (light curves, for instance) and links to Science Notebook tools and activities, relevant citizen science projects, external database links (JPL Horizons or CDS), and LSST multimedia resources. In this way, the Sky

Viewer allows for user-directed exploration and actively connects users to other features throughout the EPO Portal that encourage deeper engagement.

Through the EPO Portal, the EPO Team will make the LSST Alert Stream meaningful and useful for the public in several ways. LSST EPO will develop a broker to classify objects in the Alert Stream (details to be determined during LSST Construction) and display these objects throughout the Portal. In addition to overlays on the Sky Viewer, the EPO Portal homepage will show dynamic counters of interesting Solar System objects, Supernovae, and other transient events of interest. The EPO Team will generate listicles featuring data from the Alert Stream, that catalog interesting discoveries such as "The Top 10 closest asteroids detected by LSST" or "The most distant objects in our Solar System found by LSST to date." Such features are quickly consumable, relevant, and dynamic – a perfect fit for sharing on social media and encouraging repeat site visits by the public.

Throughout the EPO Portal, users will find articles about LSST discoveries, people involved (e.g. scientists, engineers, developers, etc.), features on LSST science results, videos that introduce the general public to LSST and its science goals, and general astronomy concepts. Features about the facility design and construction will also be available.

In addition, field research has shown that our audiences are strongly interested in what's happening in real-time with the telescope -- the current weather, what it is viewing right now, what is happening inside the dome, etc. In addition to the standard engineering facilities equipment used for Commissioning and Operations, EPO will evaluate a number of devices that could offer additional real-time metrics for the public, such as: an infrared (night-vision) camera for the dome, a fisheye webcam for the dome, and a small (~16") telescope to mount on the LSST support frame or the rotating pier base.

Evaluation of the EPO Portal will include using website analytics, surveys, and focus groups to understand how outcomes are met. Website analytics, social media analytics, and a database of community partners will be used to track who is using the EPO Portal and to ensure we are reaching a diverse audience. In addition, LSST EPO will proactively test all facets of the EPO Portal with diverse learners and those traditionally under-represented in STEM to ensure deliverables remain relevant, accessible, interesting, and engaging to diverse audiences. We will achieve this by working with community partners, minority-serving institutions, museums, libraries, and recruiters to evaluate engagement with those audiences.

Intended outcomes of the EPO Portal are:

- Increased awareness of LSST
- Increased awareness of the breadth of the LSST survey
- Increased awareness that the Universe is a dynamic place that changes on many timescales

- Increased awareness of opportunities to engage more deeply with an astronomy topic of interest

Formal Education and Data Access

Direct access to the LSST public dataset, a subset of the total data generated by LSST, will be gained through the EPO Science Notebook platform, which is also the foundation of the LSST formal education program. The Education Team will work with a diverse group of educators to develop authentic science experiences designed to improve the learner's critical thinking and evidence-based reasoning, data analysis skills, and complex problem solving abilities. These online research experiences can be life-changing for many students, and spark a deep, lifelong curiosity about discovery and science, while also improving science literacy and positive attitudes about the role that science plays in society.

The Education Team will develop easily adoptable and carefully sequenced classroom investigations that foster meaningful student collaborations and afford access to a wide range of LSST data. These investigations will be strategically chosen and designed to support the learning of topics teachers already address, while supporting key aspects of the Next-Generation Science Standards (NGSS) in the USA and goals of the Explora program through CONICYT in Chile. Investigations will be tiered, moving from more teacher-directed to more student-directed, and will be designed for students ranging from advanced middle school to high school level, and college astronomy courses for non-science majors.

The Science Notebook investigation tools will allow educators to easily modify activities to meet the needs of individual students, provide unique data samples to each student, combine the results of all students for real-time discussion, and compare class results to other classrooms around the region or world. Educators will gain access to the data, student investigation tools, classroom activities, and critical teacher support materials through the Education Hub on the EPO Portal.

To increase use and adoption of Education Hub activities in classrooms, the LSST Education Team will investigate and prototype various professional development and support options for educators, emphasizing science content knowledge and tools available to use. Professional development will be carried out at professional society meetings and educator conferences, made available online, and facilitated in collaboration with museum and library partners that can offer effective professional development. Support will be made available in the form of FAQs, training videos, and comments from other users through the EPO Portal.

The Education Team will develop a process for recognizing outstanding student or school research efforts in order to generate and maintain a level of excitement and interest in using LSST

educational products. These distinguished participants may in turn serve as examples of what can be accomplished for new users, and may inspire future directions for student research. The publicity will also help to extend awareness of LSST science beyond the school into the broader community.

Intended outcomes for educators are:

- Increased awareness of LSST and its functionality for educational purposes
- Increased confidence integrating LSST data into lessons
- Increased awareness, knowledge, and skills regarding the use of online science notebooks with their students
- Improved content knowledge and confidence using online tools through professional development activities

Individuals outside of formal education, such as amateur astronomers, those involved in citizen science campaigns, or casual EPO Portal visitors will also have access to LSST data and science notebook tools. By using the science notebooks, the public can perform intuitive queries to select objects that are of interest to them. Users can employ modules to perform work on these objects, such as viewing images and performing simple photometry, or plotting energy outputs at different wavelengths to determine the distance to objects or temperatures of stars. Activities can be guided or performed independently, with the intention being to facilitate a pathway from less-technical to more sophisticated interaction with LSST data.

To achieve this, EPO will collaborate with LSST Data Management during Construction to take advantage of synergistic opportunities, while developing interfaces and the stable functionality necessary for EPO audiences. For example, the *LSST Science Platform* will use the Jupyter family of technologies to enable data analysis by the scientific community. EPO will leverage the Jupyter modules, back-end infrastructure, and scripts developed for data analysis and then augment them with a simplified user interface that is suitable for educators, students, and the public.

Intended outcomes for data access by the general public:

- Improved knowledge of astronomy and science methods
- Increased ability to access different types of LSST images and catalog data
- Increased confidence in using data
- Increased confidence and knowledge of basic coding

Throughout beta testing during LSST Construction, the formal education and data access initiative will be evaluated using surveys, focus groups, and EPO Portal analytics to determine the extent to which developed activities support stated outcomes. Enrollment information and feedback

on professional development prototypes will be monitored to ensure that a diverse audience is reached and that an increasing number of teachers show interest.

Note: Without Internet-enabled devices, schools cannot participate in our science notebook-powered education program. Our diversity goals include engaging underserved communities that may not have the financial resources to provide enough devices to be able to participate in our programming. Therefore, LSST EPO is planning to purchase a number of tablet devices with the intention of loaning sets of them for short periods to educators that have demonstrated sincere need and strong commitment by participating in our professional development program.

Citizen Science

Because of the size of the LSST dataset, some research projects will be impractical or even impossible for individual researchers and their teams to accomplish. Citizen science allows researchers to achieve desired science results by providing a platform which enables public volunteers to contribute to the project. LSST EPO has partnered with Zooniverse[3], a popular citizen science framework and hosting service, to leverage and increase the potential for citizen science with LSST data.

The Zooniverse Project Builder[4] enables the LSST Science Community to develop citizen science projects with tools that will be specifically designed by LSST EPO to utilize LSST data. Both the annual data release catalogs and images (Level 2) and time domain alert stream (Level 1) data products can be used for LSST citizen science.

By focusing on streamlining the integration of LSST data within the Zooniverse framework and supporting self-service tools, LSST EPO will enable far more citizen science projects, and therefore science results, than could be supported solely by LSST EPO.

To promote deepening scientific engagement, EPO Portal users will be guided to citizen science projects relevant to the content they show interest in. Connecting Science Notebook investigations with citizen science projects will allow users (from students to the general public) to further explore science topics of interest and contribute to real LSST research.

To assess the success of the citizen science initiative, LSST citizen science principal investigators will be asked to document their project-building processes during the beta testing phase, and to

[3] https://www.zooniverse.org/

[4] https://www.zooniverse.org/lab

provide EPO with feedback which will be used to enable improvements. Zooniverse's analytics for the public experience will be used to document participation rates.

Intended outcomes for the citizen science initiative are:

- Awareness by the LSST Science Community of the opportunity to build LSST data-driven citizen science projects using the Project Builder
- Awareness by the LSST Science Community that they can use citizen science as a tool to achieve their science goals
- Increased skills by citizen science principal investigators at developing citizen science projects

Multimedia for Planetariums and Science Centers

Each year, there are approximately 850 million visits to American museums[5]. These museums, including informal science centers and planetariums, welcome diverse audiences and are trusted sources of information for the public. LSST EPO will develop a library of digital multimedia assets, a deliverable that reaches the maximum number of centers with the lowest barrier for adoption. The variety of video clips, images, and 3D models provided will enable content creators at these institutions to freely incorporate them as they deem best, and will also be used throughout the EPO Portal and Education Hub.

Multi-purpose media assets can also be used by educators or the general public when seeking more information about a particular topic, or if interested in a 3D tour of the LSST facility, for example. Another multi-purpose visualization we intend to develop is a 3D model of the solar system which can be used in touch screen kiosks in science centers, by formal educators for the *Earth's Place in the Universe* NGSS standard, and embedded in the EPO Portal.

LSST EPO user needs assessments so far reveal that Chilean science centers maintain a high interest in content focused on the telescope facility in Chile. Therefore contracted effort will be dedicated to capturing the construction of the telescope facility and then made available for use in media assets targeted to Chilean science centers.

Planetarium full-dome video footage will follow the *IMERSA Dome Master*[6] standards to maximize compatibility with various dome styles, projection systems, and software products. Image assets and flat-projection video footage (such as panoramas, sunset/sunrise, day/night

[5] http://www.aam-us.org/about-museums/museum-facts

[6] http://www.imersa.org/afdi-dome-standards-group

timelapse, and aerial drone) will support the *Astronomy Visualization Metadata (AVM)*[7] standard to facilitate easy searching, cataloging, and distribution via LSST's digital asset management system and the International Planetarium Society's *Data2Dome*[8] standard. Three-dimensional models (potentially summit terrain, telescope structure and facility, mirror assembly, camera assembly, etc.) will be distributed in OBJ[9] format, a common interchange format supported by all the major CAD vendors.

LSST EPO envisions a fulldome projection of the LSST night sky and a subset of LSST's alert stream data for overlaying event detection in near real-time. Event types of interest to planetarium audiences might include: supernovae, asteroids, Near Earth Objects, comets, microlensing candidates, and objects related to recent. With the large quantity of LSST alert stream data available, the display could refresh as quickly as the planetarium operator desires. EPO will contract with external multimedia specialists, video production firms, and visual effects consultants to develop additional multimedia assets over time.

Intended outcomes for content developers at informal science education facilities are:

- Increased awareness of LSST
- Increased awareness of LSST's multimedia offerings
- Increased awareness of the diversity of people working on LSST
- Increased knowledge of the main science goals of LSST
- Perception that LSST resources are easy to adopt
- Perception that LSST multimedia assets are useful for programming

Web analytics and surveys of the informal science center community and other users will be used to assess outcomes.

[7] https://www.virtualastronomy.org/avm_metadata.php

[8] http://www.data2dome.org/

[9] https://en.wikipedia.org/wiki/Wavefront_.obj_file

4 EPO Data Center

All of the initiatives described above depend on making data available in a way that is responsive to requests and easy for non-specialists to use. Therefore, a foundational component of the EPO program is a scalable data center tuned to unique EPO audience needs.

Recent surveys have shown that almost half of web users expect a site to load in less than 2 seconds, and if a site isn't fully loaded in 3 seconds, they leave.[10] In addition, the average attention span of the general public has been shown to be 8 seconds[11]. Web users are much less patient than astronomy researchers who are accustomed to batch processes, serialized data loading, and visualization processing that can take minutes, hours, or even days. Therefore, it's critical that the EPO Portal allows users to navigate quickly and smoothly around the platform.

Equally important, field research and evaluation performed by LSST EPO during Construction has confirmed that target audiences will significantly interact with LSST EPO using mobile devices, which will be accounted for in EPO interfaces and program options.

Another consideration for LSST EPO is that the user load and usage is unpredictable. Unlike astronomy research, which has a relatively small and predictable user base with known access patterns, demand for EPO products may grow quickly with word-of-mouth recommendations, social media sharing, and general popularity. Accordingly, the EPO Data Center (EDC) will follow agility best practices popularized by cloud computing, leveraging on-demand computing and auto-scalable architecture.

The easiest way to conceptualize the role of the EDC within our program is to track data as it moves from source to destination.

EPO data can be categorized as follows:

- **Alert stream:** real-time flow of text and image data
- **Animated images:** image data organized into time-series groupings with movie-like playback
- **Color images:** *ugrizy* co-added images combined to output RGB-like color images
- **Single-filter images:** co-added images from a single filter
- **Database:** tabular relational data

[10] https://blog.kissmetrics.com/speed-is-a-killer/

[11] https://advertising.microsoft.com/en/WWDocs/User/display/cl/researchreport/31966/en/microsoft-attention-spans-research-report.pdf

These data are obtained from the Data Access Center (DAC) at NCSA:

Table 1: EPO data received from the DAC

Data	Frequency	Derivative Source	Est. Quantity	Est. Size
alert stream	nightly	Community broker	10 million	400 GB
animated images	nightly	Compressed Processed Visit Image (PVI)-based images (for animation)	1,000	2.8 TB
color images	annual	Annual Data Release co-add images	*sky coverage*	243 TB
single-filter images	annual	Annual Data Release co-add images	*sample set*	1 TB
database subset	annual	Annual Data Release catalog	231 billion rows	7 TB

These data are then used by the following EPO products via required EDC infrastructure:

Table 2: Data Products that EPO will provide

Data	EPO Products	EDC Infrastructure
alert stream	• EPO Portal (Sky Viewer overlay and Object Pages) • EPO Data2Dome[12]-compliant feed (for planetarium fulldome display)	• Database • Web server
animated images	• EPO Portal (Object Pages)	• Compute processing (for adding new frames) • File storage • Web server
color images	• EPO Portal (Sky Viewer tiles and Object Pages postage stamp) • Formal Education activities • Citizen Science	• File storage • Web server
single-filter images	• EPO Portal (Object Pages postage stamps) • Formal Education activities • Citizen Science	• File storage • Web server
database subset	• EPO Portal (Sky Viewer and Object Pages metadata) • Formal Education activities	• Database • Compute processing (for Jupyter)

By designing an agile, scalable infrastructure, EPO can meet our challenging and unique audience needs while efficiently minimizing cost. As we develop these creative solutions, we anticipate that our contributions and insights can benefit future EPO programs associated with big data astronomy projects like the *Square Kilometre Array* (SKA) and thirty-meter class telescopes.

[12] http://www.data2dome.org/

5 Evaluation

The EPO evaluation plan will validate the efficacy of the EPO Design during LSST Construction, verify EPO readiness during LSST Commissioning, and establish formative feedback on learning experiences and assessment tools to be used during LSST Operations. Outcomes for each initiative are identified and will be refined during Construction. Evaluation will be carried out at the initiative level on the premise that if each initiative is successful, then EPO has successfully fulfilled its purpose.

Formative evaluation during Construction will focus on answering the following question:

- Do users find activities and deliverables intuitive?
- Are activities and deliverables accessible to our core audiences?
- Are audience needs being met?
- What are short-term user outcomes as a result of using EPO deliverables?
- Does the tested scope come in at-or under-cost estimates?
- To what extent are activities sustainable through Operations?
- How can we improve the activities to be more appropriate, efficient, effective, and sustainable?

During Commissioning, EPO will actively test deliverables with key audiences to ensure they achieve the EPO requirements listed in LSE-89, LSE-29, and LSE-30. Verification methods will include deliverable-specific testing and evaluation. Examples include documenting that deliverables (e.g. Sky Viewer) were created, testing systems (e.g. EDC, Project Builder), and compiling evaluation results.

The feedback received during formative evaluation and the testing of deliverables will serve as a baseline for summative evaluation during Operations. As part of formative evaluation, assessment tools will be developed and refined for use during Commissioning and Operations.

Table 3: Desired outcomes and key objectives with corresponding evaluation methods to validate success

EPO Deliverable	Desired Outcome / Key Objective	Evaluation Methods
EPO Portal	Serve LSST data to the general public in an accessible way	• Web analytics • Focus groups • Online feedback form • Web and social media surveys
	Engage diverse audiences and those traditionally under-represented in STEM	• Community partner surveys • Informal science center surveys • Focused recruiting interviews • Web analytics
Formal Education	Provide authentic science experiences in the classroom using LSST data	• Web analytics • Focus groups • Online feedback form • Professional development survey
Citizen Science	Allow easy creation of citizen science projects with LSST data	• Zooniverse analytics • Focus groups • Researcher surveys
Multimedia	Convey understanding of LSST science goals	• Participant surveys
	Allow easy search and adoption by content creators at informal science centers	• Standards compliance • Web analytics • Focus groups • Planetarium surveys
EPO Data Center (EDC)	Meet load and performance requirements identified in LSE-89 and LSE-131	• Load testing • Bandwidth testing • Unit testing • System testing

A summary of evaluation findings will be made publicly available. The LSST Project and Science Community will receive appropriate summarized findings during talks at annual LSST Project and Community workshops, presentations for the LSST Project Science Team, and other similar

opportunities as they arise. Summarized findings may also be presented to relevant user groups, such as teachers attending professional development workshops. Detailed findings will be presented yearly to LSST Project Management.

6 Staffing

To achieve these goals during LSST Construction, EPO will be staffed with content specialists and technicians organized into three teams: Education, Outreach, and Technical.

All three teams will be based in Tucson at LSST Headquarters and led by the Head of EPO. The Chile EPO Coordinator will be located at the base facility in La Serena, Chile and will work with all three teams. LSST EPO will also work with other AURA EPO groups to incorporate best practices and maximize efficiency.

The Education Team will develop structured online classroom activities using LSST data that reflect national education priorities and are engaging for diverse educators and students. The Education Team will be led by the Education Specialist who works with an Astronomy Software Specialist, an evaluation specialist, a web developer, and a Senior Cloud Solutions Engineer to ensure intuitive programs that run quickly, consistently, and do not exceed reasonable bandwidth requirements for broad accessibility. The Education Team will work with the Communications Team and members of the LSST science community to ensure educational activities remain relevant and up-to-date with the latest LSST discoveries.

The Outreach Team will represent LSST EPO at events, document project progress as archival footage for use in LSST Operations, and work closely with the Head of EPO to build and maintain relationships with institutional partners and organizations serving underrepresented groups in STEM. The Outreach Team will curate objects highlighted in the Sky Viewer and develop written content throughout the EPO Portal. The Outreach Team includes a graphic designer and a science writer, and works with members of the LSST science community.

The Technical Team is responsible for architecting, developing, and maintaining the EPO Data Center and keeping the system relevant to technology and internet trends over the lifetime of LSST Construction. The Technical Team will maintain and enhance EPO Portal features like the Sky Viewer, Objects Pages, and Media Library. They will also coordinate with the LSST Science Platform group, the LSST Data Facility (NCSA), and key technology partners to ensure data integrity, seamless integration, scalability, and fast performance.

Note: EPO Support during LSST Operations is similar and is described in more detail in the LSST Operations Plan (LPM-181).

7 Appendix

Operational Readiness

There are three major phases of EPO:

1. Private Beta (Construction): using simulated and precursor astronomy data sets
2. Public Beta (Commissioning): using LSST ComCam data and simulated or precursor alert stream data
3. General Availability (Operations): using LSST alert stream and production camera data

The full set of tasks for the Commissioning phase are defined in the LSST Commissioning Plan (LSE-79), but here are some EPO highlights for reference:

1. Test network bandwidth and load between NCSA and EDC
2. Test loading nightly Processed Visit Images from NCSA, converting them to animated images, and storing them in the EDC for web display
3. Test loading the public subset of annual catalog data into the EDC database
4. Test loading the color co-adds from NCSA into the EDC and converting to image tiles for Sky Viewer display
5. Test science notebook platform and run queries against the EDC data
6. Test integration of Zooniverse Project Builder with LSST data sources
7. Test EPO portal at full load using simulated users
8. Verify informal science center access to EPO multimedia
9. Validate key use cases using small groups of actual users:
   - Usability testing of Graphical User Interfaces
   - Citizen Science using prototype projects
   - Classroom activity using science notebooks
   - Multimedia search and fulldome display
10. Test cybersecurity as defined in the EPO security plan (LEP-21, LEP-22)

LSST EPO will be declared ready for Operations at the successful completion of an Operational Readiness Review (ORR) which will occur at the end of the Commissioning phase and will signal the formal end of Construction for EPO. Some key staff are expected to transition from Construction to Operations while others will be hired to provide the necessary EPO management, development, and support, as defined in the LSST Operations Plan (LPM-181).