

## LSST Data Management System Verification and Validation

LEANNE P. GUY<sup>1</sup>

<sup>1</sup>*LSST Project Office, 950 N. Cherry Ave., Tucson, AZ 85719, USA*

(Dated: September 24, 2019)

### ABSTRACT

As the Commissioning Execution Plan (LSE-390) says, "The project team shall deliver all reports documenting the as-built hardware and software including: drawings, source code, modifications, compliance exceptions, and recommendations for improvement." As a first step towards the delivery of documents that will describe the system at the end of construction, we are assembling teams for producing of the order 40 papers that eventually will be submitted to relevant professional journals. The immediate goal is to accomplish all the writing that can be done without data analysis before the data taking begins, and the team becomes much more busy and stressed.

This document provides the template for these papers.

### 1. INTRODUCTION

**Eventually, please replace all of the remaining text with your paper text.**

The LSST Construction Project team needs to document the as-built hardware and software (see LSE-79 and LSE-390 for details). Although this activity will likely continue well into the operations phase, the majority of anticipated documents will be necessary to enable efficient and robust early science with the LSST facility and thus must be available, at least in a draft form, by the first data release.

As a first step, we are now assembling teams that will be in charge of delivering these documents. An initial paper list collated by subsystem leaders includes about 40 papers that will be submitted to relevant professional journals. Therefore, this deliverable represents a major undertaking and we need to start early. In addition, the commissioning period will be shorter than anticipated due to various delays in construction and thus the time to complete these papers will be shorter, too. Although most of these papers cannot be finished before the end of construction because they will require analysis of LSST commissioning data, we can significantly mitigate the risk that they will never be finished by starting early. The early start will also help mitigate another source of stress for the team during the busy commissioning phase.

## 2. INITIAL PLAN

The subsystem leaders have assembled an initial list of papers, listed in Appendix. It is likely that this list will evolve with time. Each paper has an editor assigned to it. Each editor is meant to be a team leader who will be initially responsible for the completion of the assigned paper (or perhaps until someone else from the team assumes this leadership role). The editor is not necessarily the team member who will do most of the required work, or who will eventually become the first author. Both issues will be handled by on an individual team basis.

### 2.1. *The timeline*

We would like to have all the sections that do not depend on commissioning data written and reviewed by February 2021. If we accomplish this goal, we will both have easier time completing these papers, and the team will be less stressed during the commissioning phase.

Our initial timeline is as follows (the further into the future, the less certain it is):

1. Subsystem leads assemble the initial list of papers (DONE)
2. Setup latex templates and email exploders (lsst-constrpapers) (DONE)
3. Schedule the first telecon to discuss task, overall plan and timeline (Oct 2019).
4. Delivery of paper outlines and the second telecon (Jan 2020). Each paper outline should at least contain the list of all sections, their lead authors, and a few sentences about the section scope. Overachievers can add a list of figures etc. for extra credit.
5. First rough draft of sections that can be written without having the LSST commissioning data and the third telecon (June 2020). These drafts should at least include subsection structure, lists of planned tables, figures, rough text, and identification of any impediments to make the Oct. deadline for drafts ready for review (so that we can replan if need be).
6. Sections that can be written without having the data ready for an internal project review and the fourth telecon (Nov 2020).
7. Reviews available and the fifth telecon (Feb 2021)
8. Implementation of the reviewers' comments (from Feb 2021 until first light)
9. Final drafts, including sections that depend on LSST data, available for review and the sixth telecon (Aug 2022)
10. Implementation of the reviewers' comments (from Aug 2021 until the start of operations, planned for Oct 3, 2022). Proceeding with submissions, details TBD...

### 3. SOME TECHNICALITIES: AUTHOR LIST AND STANDARD LSST REFERENCES

Thank you Tim Jenness and Wil O'Mullane for helping with templates!

#### 3.1. *The LSST LaTeX Classes*

Please see the installation instructions<sup>1</sup> for `lsst-texmf`. Once you have it installed, you should be able to compile your paper using `make`.

#### 3.2. *How to handle author list?*

Authors come from the `authors.yaml` file – find the author ids in the `lsst-texmf/etc/authordb.yaml` - use `db2authors` to get the authors and institutes from the db.

**XXX Wil, the above is unclear: need more detail about how to use `db2authors`, what is its output and what to do with it...**

#### 3.3. *How to handle LSST standard references?*

The papers should cite standard LSST references<sup>2</sup>, where appropriate. For the usage, please see below. These examples all use the ADS handle, unless they are project docs then they use the project handle like LSE-17.

All are on the `lsst-texmf` which you can get from <http://lsst-texmf.lsst.io>

##### 3.3.1. *LSST System and Science*

The LSST system (brief overview of telescope, camera and data management subsystems), science drivers and science forecasts are described in:

- LSST Science Requirements Document: [Ivezić & The LSST Science Collaboration \(2018\)](#).
- LSST overview paper: [Ivezic et al. \(2008\)](#).
- LSST Science Book: [Abell et al. \(2009\)](#).

##### 3.3.2. *Simulations*

The LSST simulations are described in a series of papers. Use of the LSST simulations should cite the LSST simulations overview paper [Connolly et al. \(2014\)](#) and the specific simulation tools used:

- LSST Catalogs (CatSim): [Connolly et al. \(2014\)](#)
- Feature-Based Scheduler: [Naghieb et al. \(2018\)](#)
- Operations Simulator (OpSim): Scheduler [Delgado & Reuter \(2016\)](#), SOCS [Reuter et al. \(2016\)](#)

<sup>1</sup> <https://lsst-texmf.lsst.io/install.html>

<sup>2</sup> See <https://github.com/lsst-pst/LSSReferences>

- Metrics Analysis Framework (MAF): [Jones et al. \(2014\)](#)
- Image simulations (Phosim): [Peterson et al. \(2015\)](#)
- Sky brightness model: [Yoachim et al. \(2016\)](#)
- LSST Performance for NEO (or moving object) discovery: [Jones et al. \(2018\)](#)

### 3.3.3. *Data Management*

LSST data management system and the data products are described in:

- The LSST Data Management System: [Jurić et al. \(2015\)](#)
- Data Products Definition Document: [Jurić et al. \(2017\)](#)

### 3.3.4. *Camera*

- Design and development of the LSST camera: [Kahn et al. \(2010\)](#)

### 3.3.5. *Telescope and Site*

- Telescope and site overview and status in 2014: [Gressler et al. \(2014\)](#)

### 3.3.6. *System Engineering*

- LSST systems engineering: [Claver et al. \(2014\)](#)
- System verification and validation: [Selvy et al. \(2014\)](#)

## APPENDIX

### **Initial paper list added here for reference.**

“Editor” is a responsible team leader but not necessarily the person who will do most of the required work, or who will eventually become the first author. Both issues will be handled by individual teams.

domain: Telescope & Site  
 editor: Jeff Barr  
 title: Overview of the LSST Telescope

domain: Telescope & Site  
 editor: Sandrine Thomas  
 title: Performance of the LSST Telescope

domain: Telescope & Site  
 editor: Lynne Jones  
 title: The LSST Scheduler Overview and Performance

domain: Telescope & Site

editor: Bo Xin  
title: Performance of the LSST Active Optics System

domain: Telescope & Site  
editor: Tiago Ribeiro  
title: LSST Observing System Software Architecture

domain: Camera  
editor: Justin Wolfe  
title: LSST Camera Optics

domain: Camera  
editor: Chris Stubbs  
title: LSST Camera Rafts

domain: Camera  
editor: Steve Ritz  
title: LSST Camera Cryostat

domain: Camera  
editor: Ralph Schindler  
title: LSST Camera Refrigeration

domain: Camera  
editor: Steve Ritz  
title: LSST Camera Body and Mechanisms

domain: Camera  
editor: Mark Huffer and Tony Johnson  
title: LSST Camera Control System and DAQ

domain: Camera  
editor: Tim Bond and Aaron Rodman  
title: LSST Camera Integration and Tests

domain: Data Management  
editor: Leanne Guy  
title: Overview of LSST Data Management

domain: Data Management  
editor: Michelle Butler

title: LSST Data Facility

domain: Data Management

editor: Tim Jenness

title: LSST Data Management Software System

domain: Data Management

editor: Jim Bosch

title: LSST Data Release Processing

domain: Data Management

editor: Eric Bellm

title: LSST Prompt Data Products

domain: Data Management

editor: Gregory Dubois-Felsmann

title: LSST Science Platform

domain: Data Management

editor: Simon Krughoff

title: LSST Data Management Quality Assurance and Reliability Engineering

domain: Data Management

editor: Leanne Guy (with likely delegation to new DM V&V Scientist)

title: LSST Data Management System Verification and Validation

domain: Data Management

editor: Mario Juric

title: LSST Moving Object Processing

domain: Data Management

editor: Robert Lupton

title: LSST Calibration Strategy and Pipelines

domain: Calibration

editor: Patrick Ingraham

title: Performance of the LSST Calibration Systems

domain: Calibration

editor: Patrick Ingraham

title: Atmospheric Properties with the LSST Auxiliary Telescope

domain: EPO  
editor: Amanda Bauer  
title: Overview of LSST Education and Public Outreach

domain: EPO  
editor: Ardis Herrold  
title: LSST Formal Education Program

domain: EPO  
editor: Amanda Bauer  
title: LSST EPO: The User Feedback

domain: Commissioning  
editor: Chuck Claver  
title: LSST Observatory System Operations Readiness Report

domain: Commissioning  
editor: Bo Xin  
title: Performance of Delivered LSST System

domain: Commissioning  
editor: Chuck Claver  
title: Active Optics Performance with LSST Commissioning Camera

domain: Commissioning  
editor: Chuck Claver  
title: LSST Active Optics Performance with the LSST Science Camera

domain: Commissioning  
editor: Brian Stalder  
title: Integration, Test and Commissioning Results from LSST Commissioning Camera

domain: Commissioning  
editor: Kevin Reil  
title: LSST Camera Instrumental Signature Characterization, Calibration and Removal

domain: Commissioning  
editor: Patrick Hascal  
title: Installation and Performance of the LSST Camera Refrigeration System

domain: Commissioning  
 editor: Andy Connolly  
 title: Science Validation of LSST Alert Processing

domain: Commissioning  
 editor: Keith Bechtol  
 title: Science Validation of LSST Data Release Processing

domain: Commissioning  
 editor: Michael Reuter  
 title: Tracking of LSST System Performance with Continuous Integration Methods

domain: Commissioning  
 editor: Chuck Claver  
 title: The LSST Science Platform as a Commissioning Tool

domain: Commissioning  
 editor: Chuck Claver  
 title: Commissioning Science Data Quality Analysis Tools, Methods and Procedures

domain: Commissioning  
 editor: Lynne Jones  
 title: Performance Verification of the LSST Survey Scheduler

## A. REFERENCES

### REFERENCES

- |  |  |
|--|--|
| <p>Abell, P. A., Allison, J., Anderson, S. F.,<br/>       et al. 2009, <a href="#">arXiv:0912.0201</a></p> <p>Claver, C. F., Selvy, B. M., Angeli, G.,<br/>       et al. 2014, in <a href="#">Society of Photo-Optical<br/>       Instrumentation Engineers (SPIE)<br/>       Conference Series, Vol. 9150, Modeling,<br/>       Systems Engineering, and Project<br/>       Management for Astronomy VI</a>, ed.<br/>       G. Z. Angeli &amp; P. Dierickx, 0</p> | <p>Connolly, A. J., Angeli, G. Z.,<br/>       Chandrasekharan, S., et al. 2014, in<br/> <a href="#">Society of Photo-Optical<br/>       Instrumentation Engineers (SPIE)<br/>       Conference Series, Vol. 9150, Modeling,<br/>       Systems Engineering, and Project<br/>       Management for Astronomy VI</a>, ed.<br/>       G. Z. Angeli &amp; P. Dierickx, 14</p> <p>Delgado, F., &amp; Reuter, M. A. 2016, in<br/> <a href="#">Proc. SPIE, Vol. 9910, Observatory<br/>       Operations: Strategies, Processes, and<br/>       Systems VI</a>, 991013</p> |
|--|--|



- Gressler, W., DeVries, J., Hileman, E., et al. 2014, in *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, Vol. 9145, *Ground-based and Airborne Telescopes V*, ed. L. M. Stepp, R. Gilmozzi, & H. J. Hall, 1
- Ivezić, Ž., & The LSST Science Collaboration. 2018, LSST Science Requirements Document
- Ivezic, Z., et al. 2008, ArXiv e-prints, [arXiv:0805.2366](https://arxiv.org/abs/0805.2366)
- Jones, R. L., Yoachim, P., Chandrasekharan, S., et al. 2014, in *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, Vol. 9149, *Observatory Operations: Strategies, Processes, and Systems V*, ed. A. B. Peck, C. R. Benn, & R. L. Seaman, 0
- Jones, R. L., Slater, C. T., Moeyens, J., et al. 2018, *Icarus*, 303, 181
- Jurić, M., Kantor, J., Lim, K., et al. 2015, ArXiv e-prints, [arXiv:1512.07914](https://arxiv.org/abs/1512.07914) [[astro-ph.IM](https://arxiv.org/archive/astro)]
- Jurić, M., et al. 2017, LSST Data Products Definition Document
- Kahn, S. M., Kurita, N., Gilmore, K., et al. 2010, in *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, Vol. 7735, *Ground-based and Airborne Instrumentation for Astronomy III*, ed. I. S. McLean, S. K. Ramsay, & H. Takami, 0
- Naghieb, E., Yoachim, P., Vanderbei, R. J., Connolly, A. J., & Jones, R. L. 2018, arXiv e-prints, [arXiv:1810.04815](https://arxiv.org/abs/1810.04815)
- Peterson, J. R., Jernigan, J. G., Kahn, S. M., et al. 2015, *ApJS*, 218, 14
- Reuter, M. A., Cook, K. H., Delgado, F., Petry, C. E., & Ridgway, S. T. 2016, in *Proc. SPIE*, Vol. 9911, *Modeling, Systems Engineering, and Project Management for Astronomy VI*, 991125
- Selvy, B. M., Claver, C., & Angeli, G. 2014, in *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*, Vol. 9150, *Modeling, Systems Engineering, and Project Management for Astronomy VI*, ed. G. Z. Angeli & P. Dierickx, 0
- Yoachim, P., Coughlin, M., Angeli, G. Z., et al. 2016, in *Proc. SPIE*, Vol. 9910, *Observatory Operations: Strategies, Processes, and Systems VI*, 99101A

## B. ACRONYMS

| Acronym                 | Description   |
|-------------------------|---|
| Alert                   | A packet of information for each source detected with signal-to-noise ratio $\geq 5$ in a difference image during Prompt Processing, containing measurement and characterization parameters based on the past 12 months of LSST observations plus small cutouts of the single-visit, template, and difference images, distributed via the internet  |
| Butler                  | A middleware component for persisting and retrieving image datasets (raw or processed), calibration reference data, and catalogs  |
| Camera                  | The LSST subsystem responsible for the 3.2-gigapixel LSST camera, which will take more than 800 panoramic images of the sky every night. SLAC leads a consortium of Department of Energy laboratories to design and build the camera sensors, optics, electronics, cryostat, filters and filter exchange mechanism, and camera control system   |
| Commissioning           | A two-year phase at the end of the Construction project during which a technical team a) integrates the various technical components of the three subsystems; b) shows their compliance with ICDs and system-level requirements as detailed in the LSST Observatory System Specifications document (OSS, LSE-30); and c) performs science verification to show compliance with the survey performance specifications as detailed in the LSST Science Requirements Document (SRD, LPM-17)  |
| Construction            | The period during which LSST observatory facilities, components, hardware, and software are built, tested, integrated, and commissioned. Construction follows design and development and precedes operations. The LSST construction phase is funded through the NSF MREFC account   |
| DAQ                     | Data Acquisition System   |
| DM                      | Data Management   |
| Data Management         | The LSST Subsystem responsible for the Data Management System (DMS), which will capture, store, catalog, and serve the LSST dataset to the scientific community and public. The DM team is responsible for the DMS architecture, applications, middleware, infrastructure, algorithms, and Observatory Network Design. DM is a distributed team working at LSST and partner institutions, with the DM Subsystem Manager located at LSST headquarters in Tucson  |
| Data Management System  | The computing infrastructure, middleware, and applications that process, store, and enable information extraction from the LSST dataset; the DMS will process peta-scale data volume, convert raw images into a faithful representation of the universe, and archive the results in a useful form. The infrastructure layer consists of the computing, storage, networking hardware, and system software. The middleware layer handles distributed processing, data access, user interface, and system operations services. The applications layer includes the data pipelines and the science data archives' products and services |
| Data Release Processing | Deprecated term; see Data Release Production  |
| Document                | Any object (in any application supported by DocuShare or design archives such as PDMWorks or GIT) that supports project management or records milestones and deliverables of the LSST Project   |
| EPO                     | Education and Public Outreach   |

|                               |   |
|-------------------------------|---|
| Education and Public Outreach | The LSST subsystem responsible for the cyberinfrastructure, user interfaces, and outreach programs necessary to connect educators, planetaria, citizen scientists, amateur astronomers, and the general public to the transformative LSST dataset   |
| LPM                           | LSST Project Management (Document Handle)   |
| LSE                           | LSST Systems Engineering (Document Handle)  |
| LSST                          | Large Synoptic Survey Telescope   |
| LaTeX                         | (Leslie) Lamport TeX (document markup language and document preparation system)   |
| NEO                           | Near-Earth Object   |
| Object                        | In LSST nomenclature this refers to an astronomical object, such as a star, galaxy, or other physical entity. E.g., comets, asteroids are also Objects but typically called a Moving Object or a Solar System Object (SSObject). One of the DRP data products is a table of Objects detected by LSST which can be static, or change brightness or position with time  |
| OpSim                         | Operations Simulation   |
| Operations                    | The 10-year period following construction and commissioning during which the LSST Observatory conducts its survey   |
| Quality Assurance             | All activities, deliverables, services, documents, procedures or artifacts which are designed to ensure the quality of DM deliverables. This may include QC systems, in so far as they are covered in the charge described in LDM-622. Note that contrasts with the LDM-522 definition of QA as Quality Analysis, a manual process which occurs only during commissioning and operations. See also: Quality Control |
| Science Platform              | A set of integrated web applications and services deployed at the LSST Data Access Centers (DACs) through which the scientific community will access, visualize, and perform next-to-the-data analysis of the LSST data products  |
| Subsystem                     | A set of elements comprising a system within the larger LSST system that is responsible for a key technical deliverable of the project  |
| TBD                           | To Be Defined (Determined)  |
| Telescope and Site            | The LSST subsystem responsible for design and construction of the telescope structure, telescope mirrors, optical wavefront measurement and control system, telescope and observatory control systems software, and the summit and base facilities. The Telescope technical team is hosted by NOAO  |
| Validation                    | A process of confirming that the delivered system will provide its desired functionality; overall, a validation process includes the evaluation, integration, and test activities carried out at the system level to ensure that the final developed system satisfies the intent and performance of that system in operations   |
| Verification                  | The process of evaluating the design, including hardware and software - to ensure the requirements have been met; verification (of requirements) is performed by test, analysis, inspection, and/or demonstration   |
| camera                        | An imaging device mounted at a telescope focal plane, composed of optics, a shutter, a set of filters, and one or more sensors arranged in a focal plane array  |