LARGE SYNOPTIC SURVEY TELESCOPE

Large Synoptic Survey Telescope (LSST)

LSST Level 2 System Software Test Specification
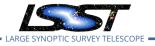
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Abstract

This document describes the detailed test specification for the LSST Level 2 System.

Contents

LSST Level 2 System Software Test Specification

1   Introduction

This document specifies the test procedure for the LSST Level 2 System.

The LSST Level 2 System is the compontent of the LSST system which is responsible for scientific processing leading to:

- Annual data release production;

- Periodic (re-) generation of calibration products;

- Periodic (re-) generation of templates for generating difference images, to be consumed in the L1 system;

- Generating QC metrics based on pipeline execution and post-processing of scientific data products.

> **Note**
>
> At time of writing, this document describes primarily a provisional series of tests to verify the correct operation of the Calibration Products Production system. This document is under rapid development during Summer 2017; it is expected to become both more comprehensive and more specific over the upcoming months.

1.1   Objectives

This document builds on the description of LSST Data Management's approach to testing as described in LDM-503 to describe the detailed tests that will be performed on the LSST Level 2 System as part of the verification of the DM system.

It identifies test designs, test cases and procedures for the tests, and the pass/fail criteria for each test. It identifies pass/fail criteria for each test.

1.2 Scope

This document describes the test procedures for the following components of the LSST system (as described in LDM-148):

- Annual Calibration

- Daily Calibration Update

- Data Release Production

- Periodic Calibration

- Raw Calibration

- Science Algorithms (partial)

- Science Primitives (partial)

- Template Generation

1.3 Applicable Documents

LDM-151   LSST DM Science Pipelines Design
LDM-294   LSST DM Organization & Management
LDM-502   The Measurement and Verification of DM Key Performance Metrics
LDM-503   LSST DM Test Plan
LSE-61   LSST DM Subsystem Requirements
LSE-163   LSST Data Products Definition Document
LSE-180   Level 2 Photometric Calibration for the LSST Survey

1.4 References

[1] **[LSE-29]**, Claver, C.F., The LSST Systems Engineering Integrated Project Team, 2016, *LSST System Requirements*, LSE-29, URL `https://ls.st/LSE-29`

[2] **[LSE-30]**, Claver, C.F., The LSST Systems Engineering Integrated Project Team, 2016, *LSST System Requirements*, LSE-30, URL `https://ls.st/LSE-30`

[3] **[LSE-61]**, Dubois-Felsmann, G., 2016, *LSST Data Management Subsystem Requirements*, LSE-61, URL `https://ls.st/LSE-61`

[4] **[LPM-17]**, Ivezić, Ž., The LSST Science Collaboration, 2011, *LSST Science Requirements Document*, LPM-17, URL `https://ls.st/LPM-17`

[5] **[LSE-180]**, Jones, L., 2013, *Level 2 Photometric Calibration for the LSST Survey*, LSE-180, URL `https://ls.st/LSE-180`

[6] **[LDM-151]**, Jurić, M., Lupton, R., et al., T.A., 2013, *Data Management Applications Design*, LDM-151, URL `https://ls.st/LDM-151`

[7] **[LSE-163]**, Juric, M., et al., 2017, *LSST Data Products Definition Document*, LSE-163, URL `https://ls.st/LSE-163`

[8] **[LDM-148]**, Kantor, J., Axelrod, T., 2013, *Data Management System Design*, LDM-148, URL `https://ls.st/LDM-148`

[9] **[LDM-502]**, Nidever, D., Economou, F., 2016, *The Measurement and Verification of DM Key Performance Metrics*, LDM-502, URL `https://ls.st/LDM-502`

[10] **[LDM-294]**, O'Mullane, W., DMLT, 2017, *Data Management Project Management Plan*, LDM-294, URL `https://ls.st/LDM-294`

[11] **[LDM-503]**, O'Mullane, W., Jurić, M., Economou, F., 2017, *Data Management Test, Verification and Validation Plan*, LDM-503, URL `https://ls.st/LDM-503`

[12] **[LSE-63]**, Tyson, T., DQA Team, Science Collaboration, 2011, *Data quality Assurance Plan: Requirements for the LSST Data Quality Assessment Framework*, LSE-63, URL `https://ls.st/LSE-63`

2   Approach

The major activities to be performed are to:

- Compare the design of the Data Release Production payload as implemented to the requirements on the outputs of the DM Subsystem as defined in LSE-63 and LSE-163 to demonstrate that all data products required by the scientific community will be delivered by the system as built.

- Ensure that all data products included in the DRP payload design are correctly produced and persisted appropriately to the LSST Data Backbone when executing a data release production.

- Compare the design of the Calibration Products payloads as implemented to the requirements laid down in LSE-63, the overall design described in LSE-180 and the inputs of the scientific pipeline payloads as described in LDM-151.

- Ensure that all data products included in the CPP payload design are correctly produced and persisted appropriately to the LSST Data Backbone and/or Calibration Database when executing a calibration products production.

- Compare the implementation of the Template Generation payloads to the inputs required by the Alert Production payload as defined in LDM-151.

- Ensure that all data products required by the L1 system are correctly produced and persisted appropriately to the LSST Data Backbone when executing a template generation production.

- Demonstrate that QC metrics are properly calculated and transmitted during the execution all L2 production types.

- Demonstrate that post-processing QC analysis of data products can be used to identify and report on failures or anomalies in the processing.

2.1 Tasks and criteria

The follwing are the major items under test:

- Science payloads capable of generating all LSST Level 2 data products;

- Calibration products payloads, run at a variety of cadences, to generate all calibration products required in the generation of LSST Level 1 and 2 data products;

- Template generation payloads capable of generating deep teamples required for difference imaging in the context of the LSST Level 1 system.

2.2 Features to be tested

- Execution of payloads described in §2.1;

- Persistence of all required data products.

2.3   Features not to be tested

This version of the LSST Level 2 System test specification addresses only the functional requirements of the systems under test, as derived from the DM System Requirements (LSE-61).

A further set of requirements which describe the scientific fidelity of the output data products are not tested in this version of this test specification pending flow-down to LSE-61.

The progress of the DM system towards satisfying the scientific requirements on LSST's data products is tracked by means of a series of Key Performance Metrics (KPMs) derived from high-level requirements documents (LPM-17, LSE-29, LSE-30). The system being used to track KPMs and to ensure compliance with these requirements is described in LDM-502.

2.4   Pass/fail criteria

The results of all tests will be assessed using the criteria described in LDM-503 §4.

Note that, when executing pipelines, tasks or individual algorithms, any unexplained or unexpected errors or warnings appearing in the associated log or on screen output must be described in the documentation for the system under test. Any warning or error for which this is not the case must be filed as a software problem report and filed be the DMCCB.

2.5   Suspension criteria and resumption requirements

Refer to individual test cases where applicable.

2.6   Naming convention

All tests are named according to the pattern prod-scope-xx-yy where:

PROD   The product code, per LDM-294. Relevant entries for this document are:

    CALDAILY   Daily CPP payload

    CPPSLOW   Periodic CPP payload

    CPPYEAR   Annual CPP payload

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TMPLGEN Template generation payload

CPPQC CPP QC measurement generators

DRP Annual mini-DRP and DRP payload

L2QC L2 QC measurement generators

CPPQC CPP QC measurement generators

SCOPE The type of test being described:

ACP Acceptance

BCK Backup and restore

FUN Functional

INS Installation

INT Integration

ITF Interface

MNT Maintenance

PRF Performance

REG Regression

VER Verification

XX Test design number (in increments of 10)

YY Test case number (in increments of 5)

3 Test Specification Design

3.1 CPPSLOW-VER-00: Calibration Product Verification

3.1.1 Objective

This test design verifies that the calibration products production pipeline as designed and built meets the overall requirements of the DM system. Specifically, we verify that:

- The design of the system is such that all calibration products required by LSE-61 are produced;

- The code as delivered is accompanied by a suite of unit tests;

- The code as delivered is accompanied by appropriate documentation;

- The code complies with all relevant DM coding standards[1];

- The code makes use of standard DM interfaces to e.g. the data backbone, the logging system, the provenance system;

- The code is built and tested by the DM continuous integration system.

Note that the tests described in this section apply to all perioically executed calibration products production payloads, regardless of cadence (the same codebase will be used for daily updates and annual calibration products production).

3.1.2　Approach refinements

The general approach defined in LDM-503 is used. Methods include:

- Document inspection;

- Code inspection;

- Review of CI system logs.

3.1.3　Test case identification

Test Case	Description
CPPSLOW-VER-00-00	CPP design inspection
CPPSLOW-VER-00-05	CPP code inspection
CPPSLOW-VER-00-10	CPP testing review

3.2　CPPSLOW-FUN-10: Periodic Calibration Product Production Data Products

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[1] https://developer.lsst.io/coding/intro.html

3.2.1   Objective

This test design verifies the existence of algorithms for generating of all periodic calibration products required by the DM System Requirements. These include:

- Bad pixel maps;

- Bias residual images;

- Crosstalk correction matrices;

- Illumination correction frames;

- Monochromatic flat fields;

- Dark current correction frames;

- Fringe correction frames.

Note that the tests described in this section apply to all perioically executed calibration products production payloads, regardless of cadence (the same codebase will be used for daily updates and annual calibration products production).

These tests demonstrate the existence of functional algorithms which calculate the required products; they are not intended to demonstrate the operation of an integrated calibration products production system.

3.2.2   Approach refinements

The general approach defined in LDM-503 is used.

The primary test method is to execute the relevant pipeline tasks on some sample input dataset and to demonstrate that an appropriate output dataset is produced.

3.2.3   Test case identification

Test Case	Description
CPPSLOW-FUN-10-00	Bad pixel map generation
CPPSLOW-FUN-10-05	Bias residual image generation

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CPPSLOW-FUN-10-10	Crosstalk correction matrix generation
CPPSLOW-FUN-10-15	Illumination correction frame generation
CPPSLOW-FUN-10-20	Monochromatic flat field generation
CPPSLOW-FUN-10-25	Dark current correction frame generation
CPPSLOW-FUN-10-30	Fringe correction frame generation
CPPSLOW-FUN-10-35	Synthetic broadband flat generation

3.3 CPPSLOW-INT-20: Periodic Calibration Product Production Integration

3.3.1 Objective

This test design verifies that all the constituent algorithms of the periodic CPP payload, tested separately in CPPSLOW-FUN-10 (§3.2), can be integrated and controlled by the LSST processing control system.

3.3.2 Approach refinements

The general approach defined in LDM-503 is used.

3.3.3 Test case identification

Test Case	Description
CPPSLOW-INT-20-00	Tests that an end-to-end calibration products pipeline can be run under manual control.
CPPSLOW-INT-20-05	Tests that the end-to-end calibration products pipeline can process data from the camera guider sensors.
CPPSLOW-INT-20-10	Tests that a complete periodic calibration products productionc an be run under the control of the LSST system.

3.4 CPPYEAR-INT-30: Annual Calibration Product Production Integration

3.4.1 Objective

This test design verifies that the annual calibration products production can be successfully carried out by the LSST processing control system.

Note that the algorithmic and integration requirements on annual calibration products update are identical to those on the periodic update, which are verified in [CPPSLOW-INT-20] (§3.3). The substantive difference over earlier specifications is simply in the volume of data which must be processed.

3.4.2   Approach refinements

The general approach defined in LDM-503 is used.

3.4.3   Test case identification

Test Case	Description
CPPYEAR-INT-30-00	Tests that the calibration products production system can perform an annual calibration product update.

3.5   CALDAILY-FUN-40: Daily Calibration Product Report

3.5.1   Objective

This test design verifies that daily calibration product updates can be produced by the LSST processing control software.

While the algorithmic components of daily calibration product updates are broadly the same as the periodic and annual updates (and thus are verified by [CPPSLOW-FUN-10]), daily processing adds some new constraints. In this test, we verify that, in addition to the calibration products themselves, a report a report describing differences in the calibration products from night to night is also generated.

3.5.2   Approach refinements

The general approach defined in LDM-503 is used.

3.5.3   Test case identification

Test Case	Description
CALDAILY-FUN-40-00	Test the production, and verify the contents, of the nightly calibration update report.

3.6 CALDAILY-INT-50: Daily Calibration Product Production System

3.6.1 Objective

The daily calibration product updates provide broadly similar algorithmic functionality to the periodic updates, and are thus verified by CPPSLOW-FUN-10 and CPPSLOW-INT-20. However, the nature of daily processing involves some extra constraints:

- The daily update is executed under the control of the Observatory Control System (OCS) driven batch processing (rather than the periodic Level 2 serivce;

- Both that report and the products themselves must be made available within a limited time so that they can be used during the night's processing.

This test specification exists to verify these goals.

3.6.2 Approach refinements

The general approach defined in LDM-503 is used.

3.6.3 Test case identification

Test Case	Description
To be written	Test the operation of calibration products production udner the control of the OCS batch processing system.
To be written	Demonstrate that nightly calibration products production, including the generation of the daily report, meets performance constraints.

4 Test Case Specification

4.1 Preparation

Before running any test case, the LSST Science Pipelines must be correctly installed. Follow the procedure described in the Pipelines Documentation.

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4.2   CPPSLOW-VER-00-00: CPP design inspection

4.2.1   Requirements

DMS-REQ-0059,DMS-REQ-0060,DMS-REQ-0061,DMS-REQ-0062,DMS-REQ-0063,DMS-REQ-0130,DMS-REQ-0132,DMS-REQ-0282,DMS-REQ-0283.

4.2.2   Test items

This test will check:

- That the design of the calibration products production pipelines is adequate to meet the DM subsystem requirements.

4.2.3   Intercase dependencies

None.

4.2.4   Procedure

By reference to LDM-151, the Science Pipelines design document, and LSE-61, the DM subsystem requirements, demonstrate that:

- The calibration products to be produced by the design outlined in LDM-151 satisfy all of the DM requirements;

- All of the calibration products to be produced are required for use by either the L1 or L2 science payloads, or have some other identified purpose.

4.3   CPPSLOW-VER-00-05: CPP code inspection

4.3.1   Requirements

DMS-REQ-0132,DMS-REQ-0158,DMS-REQ-0308.

4.3.2   Test items

This test will check:

- That the code delivered complies with relevant DM software quality standards;

- That the code is accompanied by appropriate documentation;

- That the code makes use of appropriate DM interfaces to the rest of the system where applicable;

- That the code is appropriately tested.

4.3.3   Intercase dependencies

None.

4.3.4   Procedure

- Check for the existence of a suite of unit test cases accompanying the codebase;

- Check the code to demonstrate that it is written in the standard LSST task framework and that it uses only standardized DM interfaces to logging and data access (i.e. it does not print directly to screen or perform filesystem I/O within the algorithmic code);

- Check that the code is accompanied by a user manual describing procedures for its installation and operation.

4.4   CPPSLOW-VER-00-10: CPP testing inspection

4.4.1   Requirements

DMS-REQ-0308.

4.4.2   Test items

This test will check:

- That all automated test suites associated with the product pass;

• That there are no unexpected errors or warnings from the build, test or installation pro-
cess.

4.4.3   Intercase dependencies

CPPSLOW-VER-00-05.

4.4.4   Procedure

• Check the logs from the LSST CI system which was used to build and package the soft-
ware under test to ensure:

  – Successful execution of the test suite, with no failures and no tests being skipped
  without explanatory documentation.
  – That there were no compiler, test, linter or other warnings associated with the soft-
  ware build processing.

4.5   CPPSLOW-FUN-10-00: Bad pixel map generation

4.5.1   Requirements

DMS-REQ-0059,DMS-REQ-0130.

4.5.2   Test items

This test will check:

• That a pipeline task (or equivalent tool) exists which generates a list of "bad" (unusable)
pixels for one or more CCDs.

4.5.3   Intercase dependencies

None.

4.5.4   Input specification

> **Note**
>
> Detailed specification of the inputs required to generate an appropriate list of bad pixels will require further thought & input from the Calibration Scientist; this is a work in progress.

- A pre-existing list of known-bad pixels for the CCD under test. This is a Camera Team deliverable from sensor acceptance testing.

- Dark frames corresponding to the CCD under test. (How many? Where from — do they need to be on sky, or can we generated them from the test stand?)

- Flat field frames corresponding to the CCD under test. (How many? Where from — do they need to be on sky, or can we generated them from the test stand?)

- "Pocket pumping" exposures corresponding to the CCD under test. (How many? Where from — do they need to be on sky, or can we generated them from the test stand?)

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.5.5   Output specification

- A list of bad pixels in the CCD under test.

These products should be persisted to a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.5.6   Procedure

The task for generating bad pixel masks will be executed from the command line, with a configuration appropriate for it to fetch required input data from the input Butler repository.

The resulting bad pixel list will be persisted to the output repository. To check for correctness, it should be:

- Compared to the initial list of bad pixels provided by the Camera Team;

- Optionally overplotted on the input data for manual inspection.

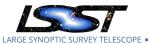## 4.6   CPPSLOW-FUN-10-05: Bias residual image generation

4.6.1   Requirements

DMS-REQ-0060,DMS-REQ-0130.

4.6.2   Test items

This test will check:

- That a pipeline task (or equivalent tool) exists which generates a master image which can be used to correct for temporally stable bias structure in data from a CCD.

4.6.3   Intercase dependencies

None.

4.6.4   Input specification

> **Note**
>
> Detailed specification of the inputs required will require further thought & input from the Calibration Scientist; this is a work in progress.

- Multiple (how many?) zero-second exposures of the CCD under test.

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.6.5   Output specification
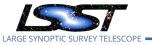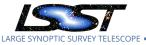
- A master bias residual image.

These products should be persisted to a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.6.6   Procedure

The task for generating the master bias residual image will be executed from the command line, with a configuration appropriate for it to fetch required input data from the input Butler repository.

The resulting master bias will be persisted to the output repository. It should be retrieved from the output repository using the Butler and checked to ensure it contains physically plausible values (TBD by the Calibration Scientist).

4.7   CPPSLOW-FUN-10-10: Crosstalk correction matrix generation

4.7.1   Requirements

DMS-REQ-0061,DMS-REQ-0130.

4.7.2   Test items

This test will check:

- That a pipeline task (or equivalent tool) exists which generates a matrix describing the fraction of the signal detected in any given amplifier on each sensor in the focal plane appears in any other amplifier.

Note that crosstalk is sensitive to the details of the camera configuration (circuit board locations, cable flex, etc), and so the final values of the crosstalk correction matrix cannot be measured until the camera is in situ on the mountain (and even then they may continue to evolve, necessitating periodic re-measurement). However, this test verifies the operation of the algorithm for generating the matrix, not the values used in operation, so this test does not need to be run with the camera in its final configuration.

4.7.3   Intercase dependencies

None.

4.7.4 Input specification

> **Note**
>
> Detailed specification of the inputs required will require further thought & input from the Calibration Scientist; this is a work in progress.

- Dithered Colliated Beam Projector (CBP) observations with the full camera or a representative subset thereof.

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.7.5 Output specification

- A crosstalk correction matrix.

These products should be persisted to a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.7.6 Procedure

The task for generating the crosstalk correction matrix will be executed from the command line, with a configuration appropriate for it to fetch required input data from the input Butler repository.

The resulting crosstalk correction matrix will be persisted to the output repository. It should be retrieved from the output repository using the Butler and checked to ensure it contains physically plausible values (TBD by the Calibration Scientist).

4.8 CPPSLOW-FUN-10-15: Illumination correction frame generation

4.8.1 Requirements

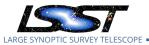DMS-REQ-0062,DMS-REQ-0130.

4.8.2 Test items

This test will check:

- That a pipeline task (or equivalent tool) exists which generates an image that corrects for the non-uniform illumination of the flat field screen.

4.8.3 Intercase dependencies

None.

4.8.4 Input specification

> **Note**
>
> Detailed specification of the inputs required will require further thought & input from the Calibration Scientist; this is a work in progress.

- Collimated Beam Projector (CBP) images as specified in LDM-151 §4.2.10.

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.8.5 Output specification

- An illumination correction image.

These products should be persisted to a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.
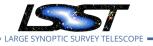
4.8.6 Procedure

The task for generating the illumination correction frame will be executed from the command line, with a configuration appropriate for it to fetch required input data from the input Butler repository.

The resulting illumination correction image will be persisted to the output repository. It should be retrieved from the output repository using the Butler and checked to ensure it contains physically plausible values (TBD by the Calibration Scientist; ultimately, per LSE-61, it will be verified by application to operational data).

4.9 CPPSLOW-FUN-10-20: Monochromatic flat field generation

4.9.1 Requirements

DMS-REQ-0063,DMS-REQ-0130.

4.9.2 Test items

This test will check:

- That a pipeline task (or equivalent tool) exists which generates an set of master pure monochromatic flat field images.

4.9.3 Intercase dependencies

CPPSLOW-FUN-10-05, CPPSLOW-FUN-10-15, CPPSLOW-FUN-10-25.

4.9.4 Input specification

> **Note**
>
> Detailed specification of the inputs required will require further thought & input from the Calibration Scientist; this is a work in progress.

- Monochromatic flat field images;
- Collimated Beam Projector (CBP) images as specified in LDM-151 §4.2.10.

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.
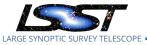
4.9.5   Output specification

- A monochromatic flat field data cube.

These products should be persisted to a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.9.6   Procedure

Tasks for assembling, bias correcting and dark correcting the monochromatic flat field images will be executed from the command line, and the results persisted to a data repository. These serve as inputs to the monochromatic flat field data cube production.

The task for generating the monochromatic flat field data cube will be executed from the command line, and the results persisted to a further data repository.

The Butler will be used to retrieve the flat field data cube from the output repository, and the contents checked to ensure they are physically plausible (values TBD by the Calibration Scientist.)

4.10   CPPSLOW-FUN-10-25: Dark current correction frame generation

4.10.1   Requirements

DMS-REQ-0063,DMS-REQ-0282.

4.10.2   Test items

This test will check:

- That a pipeline task (or equivalent tool) exists which generates a coadded dark current correction image.

4.10.3   Intercase dependencies

> **Note**
>
> LDM-151 notes that we need to perform standard ISR on the darks before combining them, so that likely means a call out to a single frame/ISR test case when it exists.
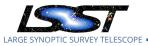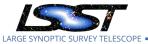
CPPSLOW-FUN-10-05.

4.10.4   Input specification

> **Note**
>
> Detailed specification of the inputs required will require further thought & input from the Calibration Scientist; this is a work in progress.

- Multiple individual dark exposures of a single CCD with exposure times of 300 s.

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.10.5   Output specification

- A coadded dark current correction frame.

These products should be persisted to a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.10.6   Procedure

The instrument signature removal code will be run on the individual input exposures from the command line, and the results persisted to a data repository.

The task for generating the coadded dark current correction frame will be executed from the command line, and the results persisted to a further data repository.

The Butler will be used to retrieve the flat field data cube from the output repository, and the contents checked to ensure they are physically plausible (values TBD by the Calibration Scientist.)

4.11 CPPSLOW-FUN-10-30: Fringe correction frame generation

4.11.1 Requirements

DMS-REQ-0063,DMS-REQ-0283.

4.11.2 Test items

This test will check:

- That a pipeline task (or equivalent tool) exists which generates an image which corrects for detector fringing.

4.11.3 Intercase dependencies

CPP-SLOW-FUN-10-20.

4.11.4 Input specification

> **Note**
>
> Detailed specification of the inputs required will require further thought & input from the Calibration Scientist; this is a work in progress.

- Monochromatic flat field data cube.

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.11.5 Output specification
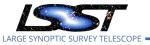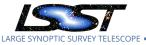
- An image that corrects for fringing.

These products should be persisted to a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.11.6 Procedure

The task for generating the fringe correction frame will be executed from the command line, with a configuration appropriate for it to fetch required input data from the input Butler repository.

The resulting fringe correction frame will be persisted to the output repository. It should be retreived from the output repository using the Butler and checked to ensure it contains physically plausible values (TBD by the Calibration Scientist).

4.12 CPPSLOW-FUN-10-35: Synthetic broadband flat generation

4.12.1 Requirements

DMS-REQ-0130.

4.12.2 Test items

This test will check:

- That a pipeline task (or equivalent tool) exists which generates a synthetic broad-band flat for each filter in use with the LSST system.

4.12.3 Intercase dependencies

CPPSLOW-FUN-10-20.

4.12.4 Input specification

> **Note**
>
> Detailed specification of the inputs required will require further thought & input from the Calibration Scientist; this is a work in progress.

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- Monochromatic flat field data cube covering all filters.

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.12.5 Output specification

- One synthetic broadband flat field image for the CCD being tested for each filter.

These products should be persisted to a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.12.6 Procedure

The task (or tasks, if one per filter; final design TBD) for generating the broadband synthetic flat field image will be executed from the command line, with a configuration appropriate for it to fetch required input data from the input Butler repository.

The resulting broadband synthetic flats will be persisted to the output repository. They should be retreived from the output repository using the Butler and checked to ensure they contain physically plausible values (TBD by the Calibration Scientist).

4.13 CPPSLOW-INT-20-00: Manual Calibration Products Production Execution

4.13.1 Requirements
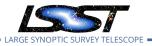
DMS-REQ-0059,DMS-REQ-0060,DMS-REQ-0061,DMS-REQ-0062,DMS-REQ-0063,DMS-REQ-0130,DMS-REQ-0282,DMS-REQ-0283,DMS-REQ-0289,DMS-REQ-0308.

4.13.2 Test items

This test will check:

- That a single point of entry exists, in the form of a command line task or equivalent tool, which provides all the necessary functionality and configuration to perform a periodic calibration products production.

4.13.3   Intercase dependencies

Generating a complete set of calibration products depends on successful completion of:
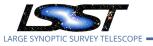
- CPPSLOW-VER-00-00

- CPPSLOW-VER-00-05

- CPPSLOW-VER-00-10

- CPPSLOW-FUN-10-00

- CPPSLOW-FUN-10-05

- CPPSLOW-FUN-10-10

- CPPSLOW-FUN-10-15

- CPPSLOW-FUN-10-20

- CPPSLOW-FUN-10-25

- CPPSLOW-FUN-10-30

- CPPSLOW-FUN-10-35

However, this test case may also be executed at intermediate stages during construction to test the production of only a limited set of calibration products, and the dependency list may be reduced as appropraite.

4.13.4   Input specification

A Butler data repository with all required inputs for the calibration products production loaded. This includes:

- Dark frames corresponding to the CCDs under test;

- Flat field frames corresponding to the CCDs under test;

- Pocket pumping exposures corresponding to the CCDs under test;

- Zero-second exposures of the CCDs under test;

- Collimated Beam Projector observations per LDM-151 §4.2.10;

- Monochromatic flat field images corresponding to the CCDs under test.

In addition, a pipeline configuration will be specified which includes details of the input repository and (if necessary) any configuration overrides required to process the data under test[2].

4.13.5   Output specification

A Butler data repository should be populated with all the required period Calibration Products Production data products, to include:
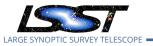
- Bad pixel lists;

- Bias images;

- Crosstalk correction matrices;

- Illumination correction frames;

- Monochromatic flat field data cubes;

- Broad-band synthetic flats;

- Dark current correction frames;

- Fringe correction frames.

4.13.6   Procedure

The Calibration Products Pipeline will be invoked manually from the command line, being provided with the configuration file needed.

At the end of processing, all of the outputs specified shall be available for retrieval from the Butler data repository.

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[2]The default pipeline configuration should be appropriate for full LSST camera images, but may need adjusting to match the test conditions or input data source.

4.14   CPPSLOW-INT-20-05: Calibration Products from Guider Sensors

4.14.1   Requirements

DMS-REQ-0265.

4.14.2   Test items

This test will check:

- That all calibration products are available for processing camera guide sensors.

4.14.3   Intercase dependencies

CPP-SLOW-INT-20-00.

4.14.4   Input specification

As for CPPSLOW-INT-20-00, but with the additional requirement that at least one of the CCDs under test must be a guider sensor.

4.14.5   Output specification
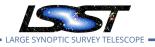
As for CPPSLOW-INT-20-00.

4.14.6   Procedure

As for CPPSLOW-INT-20-00.

4.15   CPPSLOW-INT-20-10: Periodic Calibration Products Production Service

4.15.1   Requirements

DMS-REQ-0059,DMS-REQ-0060,DMS-REQ-0061,DMS-REQ-0062,DMS-REQ-0063,DMS-REQ-0130,DMS-REQ-0132,DMS-REQ-0265,DMS-REQ-0282,DMS-REQ-0283,DMS-REQ-0289,DMS-REQ-0294,DMS-REQ-0314,DMS-REQ-0346.

4.15.2 Test items

This test will check:

- That a service exists which will execute the periodic Calibration Products Production payload;

- That all data products required are produced and persisted when that payload is executed;

- That provenance information about the production is recorded appropriately;

- That input data is retained at the end of the production.

4.15.3 Intercase dependencies

> **Note**
>
> Also dependent on various pieces of compute middleware and the hardware system, for which test cases have not yet been written.

- CPPSLOW-INT-20-00,

- CPPSLOW-INT-20-05.

4.15.4 Input specification

The same input is required as for CPPSLOW-INT-20-05, with the additional caveat that the repository containing the data must be available and accessible using the Data Backbone.
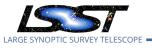
4.15.5 Output specification

As for CPPSLOW-INT-20-05, with the additional caveats that:

- Information must be persisted to the Data Backbone, not simply to a locally accessible repository;

- *Input* data must be demontrated to remain available and unchanged on the Data Backbone at the end of the test.

In addition, metadata describing the provenance of the data products must be recorded and made available for inspection.

4.15.6 Procedure

A periodic calibration products production is scheduled and executed using the Template & Calibration Products Periodic Execution Service (LDM-148).

The operator will monitor system logs and check for successful execution of the service.

At the end of the service, all products specified in the output specification above must be accessible on the Data Backbone. They should be retrieved and checked for validity by the operator (or designated representative).

4.16 CPPYEAR-INT-30-00: Annual Calibration Products Production Service
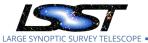
4.16.1 Requirements

DMS-REQ-0059,DMS-REQ-0060,DMS-REQ-0061,DMS-REQ-0062,DMS-REQ-0063,DMS-REQ-0130,DMS-REQ-0132,DMS-REQ-0265,DMS-REQ-0282,DMS-REQ-0283,DMS-REQ-0289,DMS-REQ-0294,DMS-REQ-0314,DMS-REQ-0346.

4.16.2 Test items

This test will check:

- That a service is available which is capable of performing the annual calibration products update.

4.16.3   Intercase dependencies

> **Note**
>
> Also dependent on various pieces of compute middleware and the hardware system, for which test cases have not yet been written.

cppslow-int-20-10 [CPPSLOW-INT-20-10]

4.16.4   Input specification

The same input is required as for CPPSLOW-INT-20-10, with the additional caveat that a full year's worth of (possibly simulated) input data must be available for processing.

4.16.5   Output specification

As for CPPSLOW-INT-20-10.

4.16.6   Procedure

As for CPPSLOW-INT-20-10.

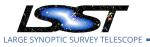## 4.17   CALDAILY-FUN-40-00: Bad pixel map generation

4.17.1   Requirements

DMS-REQ-0101.

4.17.2   Test items

This test will check:

- That the daily calibration products update produces a report describing the evolution of calibration products from night to night;

- The daily calibration products report must include a broadband flat in each filter.

4.17.3 Intercase dependencies

- CPPSLOW-FUN-10-35

4.17.4 Input specification

As for CPPSLOW-INT-20-00, but corresponding to *two* nights of data acquisition.

These products should be available within a Butler repository accessible through the regular LSST data access framework from the system on which the test is being run.

4.17.5 Output specification

- A calibration report describing the evolution of the calibration products between the two nights under test.

4.17.6 Procedure

The daily calibration products update pipeline is invoked for the first night under test, and the results persisted to an output repository.

The daily calibration products update pipeline is invoked for the second night under test, and the results persisted to an output repository.

The operator should be presented (in a form TBD) with a test report, describing the evolution of the calibration products from the first to the second night. The detailed contents of this report are TBD.

The operator should verify that broadband flats, in each filter, are available from the output repository for both nights under test.