



Data Management System (DMS) Requirements

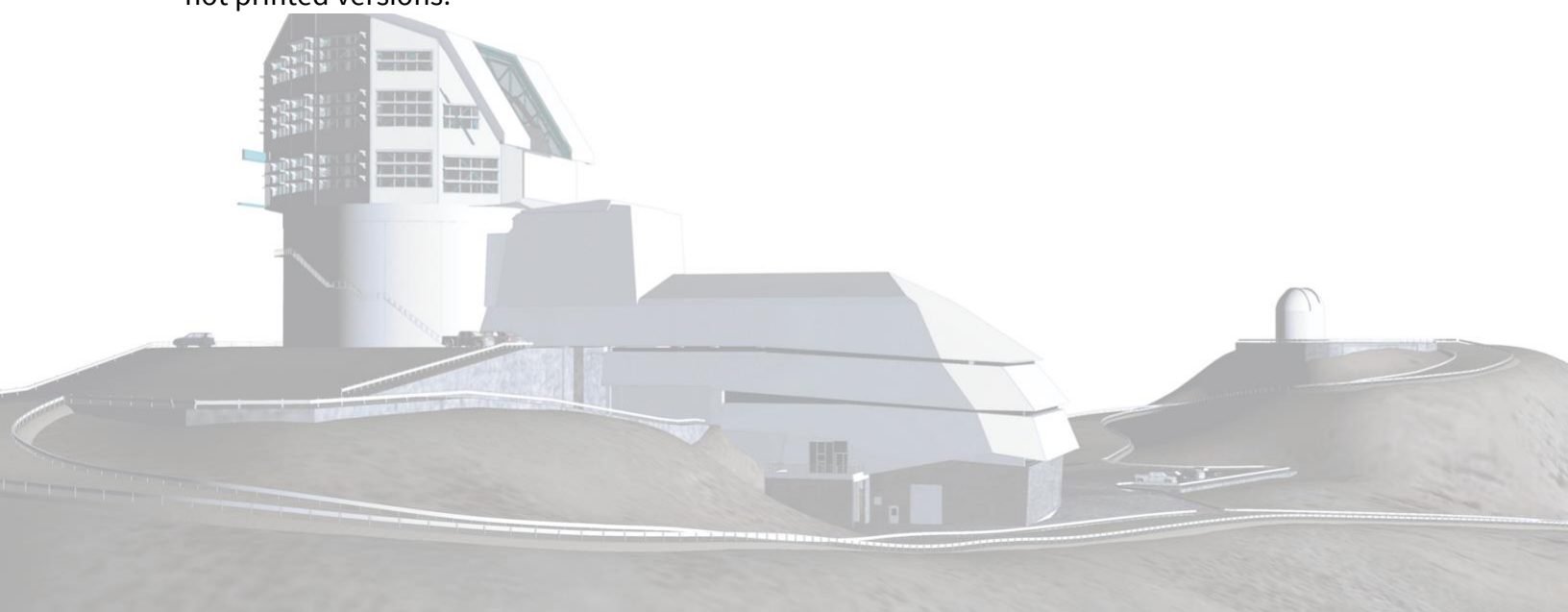
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LSE-61 (rel10.2.1)

<https://doi.org/10.71929/rubin/2587200>

Latest Revision Date: September 15, 2025

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Change Record

Release	Date	Description	Owner Name
0.1	2007	Initial version	G. Dubois-Felsmann
0.5	2009 Feb	Approved as a content-controlled document by the CCB.	G. Dubois-Felsmann
1.0	2011-06-28	Captured DM Functional Requirements Specification as version 1 of new document LSE-61.	G. Dubois-Felsmann
1.1	2011-08-03	Requirements numbering applied. Original numbering preserved for a transition period.	G. Dubois-Felsmann
2.0	2013-10-08	Extensive reorganization and partial rewrite; corresponds to CVS revision 1.44 in SysArch.	D. Shaw, M. Juric, G. Dubois-Felsmann
2.0.1	2013-10-08	Corrections affecting DMS-REQ-0176, -0267, -0268, -0287, and the creation of -0317. CVS revision 1.45.	G. Dubois-Felsmann
2.0.2	2017-09-21	Editorial correction and new format from software transition. No content change. Still release 4.0.	K. Wesson
3.0	2013-10-08	Incorrect statements removed from Discussion in DMS-REQ-0271 and DMS-REQ-0283, many typos corrected. CVS	G. Dubois-Felsmann and B. Selvy

		revision 1.46.	
4.0	2017-06-30	Incorporation of LCR-962. Flowdown from LSE-163. Remove DMS-REQ-0006. Incorporate LCR-974. Add DMS-REQ-0352.	T. Jenness
4.1	2017-08-11	Incorporation of LCR-921. Add DMS-REQ-0353.	T. Jenness
4.2	2017-09-12	Incorporation of LCR-1064. Add priorities.	T. Jenness
4.3	2018-01-09	Incorporation of LCR-1024: Add DPDD flowdown from OSS.	T. Jenness
4.4	2018-03-19	Incorporation of LCR-908 and LCR-1238	Model: R.Carlson; Docgen: G. Comoretto
4.5	2018-06-27	Incorporation of LCR-983 and LCR-1309	Model: R.Carlson; Docgen: T. Jenness
5.0	2018-09-18	Incorporation of LCR-1344 (Performance Metrics)	T. Jenness
6.0	2019-03-08	Twelve new requirements. Incorporation of LCR-1465 (Provenance flowdown from LSE-30), LCR-1463 (Alert Packet DIASource History Retention), and LCR-1425 (Include HiPS & MOC Data Creation & Display)	Model: T. Jenness, M. Rodriguez, K-T Lim; Docgen: T. Jenness

7.0	2019-10-07	Implementation of LCR-1883 (Alert-Related Content Clarification). Exported with new template including traceability.	M. Graham
7.1	2019-10-10	Implementation of LCR-1203, LCR-1554, LCR-1915, LCR-2004, LCR-2008	C. Claver (LCR-1203), G. Dubois-Felsmann (LCR-1554), B. Kalmbach (LCR-1915), S. Schmidt (LCR-2004), T. Jenness (LCR-2008)
8.0	2019-12-03	Implementation of LCR-1664, LCR-1933	S. Krughoff (LCR-1664), W. O'Mullane (LCR-1933)
8.1	2020-02-21	Implementation of LCR-1923, LCR-2166. Removed "Deleted Requirements" section and moved the requirements as "Descoped" requirements in the main section of the document.	V. Riot (LCR-1923), J. Kantor (LCR-2166)
8.2	2020-04-08	Implementation of LCR-2243.	G. Dubois-Felsmann
8.3	2020-05-04	Implementation of LCR-2265.	M. Graham
8.4	2020-05-19	Implementation of LCR-2273.	E. Bellm

8.5	2020-10-21	Implementation of LCR-2376, LCR-2378, and LCR-2415.	M. Juric (LCR-2376), G. Dubois-Felsmann (LCR-2378, LCR-2415)
9.0	2020-02-12	Implementation of LCR-2543.	L. Guy
9.1	2022-12-12	Implementation of LCR-3285 and LCR-3293.	L. Guy
10.0	2023-11-21	Implementation of LCR-3543	W. O'Mullane
10.1	2024-02-21	Implementation of LCR-3683	J. Carlin
10.1	2023-12-15	Implementation of LCR-3643	J. Carlin
10.2	2024-08-21	Implementation of LCR-3831	E. Bellm
10.2.1	2025-09-15	Add DOI	T.Jenness

Latest document version generated from model version #2181.

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LSE-61 Data Management System (DMS)

Requirements

Introduction and Scope

This document contains the top-level requirements for the Data Management subsystem of the LSST, when combined with the Data Management-related requirements in the LSST System Requirements (LSR, LSE-29) and Observatory System Specifications (OSS, LSE-30).

Supporting Documents

1. LSST Science Requirements Document (document LPM-17)
2. LSST System Requirements (document LSE-29)
3. LSST Observatory System Specifications (document LSE-30)
4. LSST Document Tree (document LSE-39)

Definition of Terms

In this document a **requirement** refers to a declaration of a specified function or quantitative performance that the delivered system or subsystem must meet. It is a statement that identifies a necessary attribute, capability, characteristic, or quality of a system in order for the delivered system or subsystem to meet a derived or higher requirement, constraint, or function.

This document uses the term **specification(s)** to mean one or more performance

parameter(s) being established by a requirement that the delivered system or subsystem must meet.

An **attribute** specifies a quantitative performance **parameter** in the context of the SysML based SysArch model used to generate this document.

A **constraint** is used to refer to an external limitation imposed on a delivered item under which it must meet its requirements (e.g., the survey performance must be met under the constraint of the historical weather pattern of the chosen site). A constraint is not a characteristic the system or subsystem itself possesses.

Verb Usage

Statements of need, requirements, and constraints are written using one of three verbs that have a specific meaning with respect to verification. All statements in this specification that convey operational, functional, or performance needs, requirements, constraints, or goals on the LSST system will contain one of these three verbs.

- **Will** – A statement of fact. Will statements document something that will occur through the course of normal design practice, project process, etc. These statements do not get formally verified.
- **Should** – A goal. Should statements document a stretch goal. A should statement is typically partnered with a shall statement. Should statements do not get formally

verified.

- **Shall** - A requirement that gets formally verified. Shall statements document critical requirements that must be verified through inspection, demonstration, analysis, or test during the verification phase of the project to ensure objectively that the as-built design meets the requirement.

Prioritization

1. "This must be done to enter commissioning (a) or operations (b); no waivers will be granted if not met."
 - **1a:** Must be demonstrated to be working before the start of the commissioning period.
 - **1b:** Must be demonstrated to be working before the start of the observing.
2. "Should be done to enter Operations; but waiver likely to be granted if not met," i.e., we could enter Operations without this fulfilled, for first 3 years.
3. "Overall capability/efficiency/ease of use/etc., may be reduced but science will not critically suffer if not done." Could enter operations without this requirement fulfilled, and have the operations team decide whether they want to pursue it.

LSE-61 Data Management System (DMS)

Requirements

1 Data Products

1.1 General Considerations

1.1.1 Data Availability

ID: DMS-REQ-0346 (Priority: 1b)

Specification: All raw data used to generate any public data product (raw exposures, calibration frames, telemetry, configuration metadata, etc.) shall be kept and made available for download.

Derived from requirements:

OSS-REQ-0004: The Archive Facility

OSS-REQ-0167: Data Archiving

OSS-REQ-0313: Telemetry Database Retention

1.1.2 Measurements in catalogs

ID: DMS-REQ-0347 (Priority: 1b)

Specification: All catalogs shall record source measurements in fluxes, reported in

nanojansky.

Discussion: Difference measurements can go negative and in multi-epoch surveys averaging of fluxes rather than magnitudes is required. This requirement does not preclude making magnitudes available where appropriate. The rationale for the use of nanojanskys is presented in Document-27758.

Derived from requirements:

OSS-REQ-0391: Data Product Conventions

Impacted by LCR(s):

Updated per LCR-2378

1.1.3 Computing Derived Quantities

ID: DMS-REQ-0331 (Priority: 1b)

Specification: Common derived quantities shall be made available to end-users by either providing pre-computed columns or providing functions that can be used dynamically in queries. These should at least include the ability to calculate the reduced chi-squared of fitted models and make it as easy as possible to calculate color-color diagrams.

Discussion: Example quantities include those used to assess model fit quality or those required for calculating color-magnitude diagrams. Care should be taken to name the derived columns in a clear unambiguous way.

Derived from requirements:

OSS-REQ-0391: Data Product Conventions

1.1.4 Denormalizing Database Tables

ID: DMS-REQ-0332 (Priority: 2)

Specification: The database tables shall contain views presented to the users that will be appropriately denormalized for ease of use.

Derived from requirements:

OSS-REQ-0133: Level 2 Data Products

1.1.5 Maximum Likelihood Values and Covariances

ID: DMS-REQ-0333 (Priority: 1b)

Specification: Quantities delivered by all measurement algorithms shall include maximum likelihood values and covariances.

Discussion: Algorithms for which such values are impossible, will be documented explicitly to declare that the values are unavailable.

Derived from requirements:

OSS-REQ-0391: Data Product Conventions

1.1.6 Storing Approximations of Per-pixel Metadata

ID: DMS-REQ-0326 (Priority: 2)

Specification: Image depth and mask information shall be available in a parametrized approximate form in addition to a full per-pixel form.

Discussion: This parametrization could be in formats such as MOC, Mangle polygons, or STC regions. Note that, under requirements DMS-REQ-0383 and DMS-REQ-0379, MOCs for the survey coverage as a simple Boolean map are required to be generated; the present requirement covers maps providing additional information as a function of sky position.

Derived from requirements:

OSS-REQ-0391: Data Product Conventions

1.1.7 Scientific Visualization of Camera Image Data

ID: DMS-REQ-0395 (Priority: 1a)

Specification: All scientific visualization of camera image data shall use the coordinate systems defined in LSE-349.

Derived from requirements:

OSS-REQ-0408: Scientific Visualization of Camera Image Data

Impacted by LCR(s):

Added per LCR-1664

1.2 Data Acquisition

1.2.1 Raw Image Assembly

ID: DMS-REQ-0024 (Priority: 1a)

Specification: The DMS shall assemble the combination of raw exposure data from all the readout channels from a single Sensor to form a single image for that sensor. The image data and relevant exposure metadata shall be integrated into a standard format suitable for downstream processing, archiving, and distribution to the user community.

Discussion: Relevant exposure metadata are those that define the observing context, telescope and instrument configuration, and provenance.

Derived from requirements:

OSS-REQ-0114: Acquisition of Science Sensor data

OSS-REQ-0129: Exposures (Level 1)

1.2.2 Raw Science Image Data Acquisition

ID: DMS-REQ-0018 (Priority: 1a)

Specification: The DMS shall acquire raw Exposure data from the Camera science sensors during normal operations, calibration data collection, and in any other required engineering

modes.

Discussion: The manner of data acquisition is a matter for the DM-Camera ICDs, LSE-69 and LSE-68, in this area.

Derived from requirements:

OSS-REQ-0114: Acquisition of Science Sensor data

1.2.3 Raw Science Image Metadata

ID: DMS-REQ-0068 (Priority: 1a)

Specification: For each raw science image, the DMS shall store image metadata including at least:

- Time of exposure start and end, referenced to TAI, and DUT1
- Site metadata (site seeing, transparency, weather, observatory location)
- Telescope metadata (telescope pointing, active optics state, environmental state)
- Camera metadata (shutter trajectory, wavefront sensors, environmental state)
- Program metadata (identifier for main survey, deep drilling, etc.)
- Scheduler metadata (visitID, intended number of exposures in the visit)

Discussion: The program metadata should be sufficient to associate an image with a specific Special Program so that DMS-REQ-0320 and DMS-REQ-0397 can be satisfied. The scheduler metadata should sufficiently inform the processing pipelines regarding e.g., deviations from 2-snap 30 second visits, so that computational resources can be appropriately allocated, and so that DMS-REQ-0320 can be satisfied.

Derived from requirements:

OSS-REQ-0122: Provenance

OSS-REQ-0171: Engineering and Facilities Data

DMS-REQ-0320: Processing of Data From Special Programs

Impacted by LCR(s):

Updated per LCR-2265

1.2.4 (Descoped) ~~Crosstalk-Corrected Science Image Data Acquisition~~

ID: DMS-REQ-0022 (Priority: 2)

Specification: ~~The DMS shall acquire crosstalk-corrected exposure data from the Camera science sensors, during normal survey operations and in any other required operating modes.~~

Discussion: ~~The manner of data acquisition is a matter for the DM Camera ICD in this area. It may be different for that for the raw science sensor data, as it is subject to quite different latency and reliability requirements. This data is the input to the main Alert Production pipelines. It is not planned to be archived.~~

Impacted by LCR(s):

Descoped per LCR-1923

1.2.5 Wavefront Sensor Data Acquisition

ID: DMS-REQ-0020 (Priority: 1a)

Specification: The DMS shall acquire raw exposure data from the Camera wavefront sensors, during normal survey operations and in any other required operating modes.

Discussion: The details of this are a matter for the DM-Camera ICD in this area. However, these data should be identical in format and in mode of acquisition to the raw science sensor data. There is no currently established requirement for the acquisition or archiving of any raw guider sensor data.

Derived from requirements:

OSS-REQ-0316: Wavefront Sensor Data

1.2.6 Guider Calibration Data Acquisition

ID: DMS-REQ-0265 (Priority: 1a)

Specification: The DMS shall acquire raw, full-frame exposures from the camera guider sensors during calibration. The DMS shall produce calibration data products for the guide sensors.

Derived from requirements:

OSS-REQ-0194: Calibration Exposures Per Day

1.3 Level 1 Data Products

1.3.1 Level 1 Data Product Availability

ID: DMS-REQ-0004 (Priority: 1b)

Specification: All Level 1 Data Products except Transient Alerts, Solar System Objects, and images shall be produced and made available to the consortium not later than **L1PublicT** of the acquisition of the corresponding raw images.

Discussion: Level 1 Data Products will in general arise from either the nightly Alert Production or from the daily processing of each night's data, and will be released to the public promptly following the completion of processing.

Description	Value	Unit	Name
Maximum time from the acquisition of science data to the release of associated Level 1 Data Products (except alerts)	24	hour	L1PublicT

The instantaneous peak number of alerts per standard visit.	40000	integer	nAlertVisitPeak
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Derived from requirements:

OSS-REQ-0127: Level 1 Data Product Availability

Impacted by LCR(s):

Updated per LCR-1883

Updated per LCR-1933

Updated per LCR-3543

1.3.1.1 Level 1 Data Product Embargo

ID: DMS-REQ-0402 (Priority: 1a)

Specification: Rubin Observatory shall not release image data resulting from a visit, except for the content of the public alert stream, sooner than time **L1EmbargoTMin** following the acquisition of the raw image data from that visit.

Discussion: QA personnel would be allowed to look at these images before **L1EmbargoTMin** should it be necessary for QA purposes.

Description	Value	Unit	Name
-------------	-------	------	------

Time images and other products (except alerts) will be embargoed before release to the consortium (or the public)	80	hour	L1EmbargoTMin
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Derived from requirements:

OSS-REQ-0411: Level 1 Data Product Embargo

Impacted by LCR(s):

Added per LCR-3543

1.3.1.1.1 Level 1 Data Product Pixel Data Embargo in Operations

ID: DMS-REQ-0403 (Priority: 1b)

Specification: Rubin Observatory pixel data shall be held in a secure location and not released to the consortium prior to **L1EmbargoTMin** and no later than **L1EmbargoT** after data acquisition during the Operations phase.

Specification: Certain images may be held longer at the discretion of the agencies.

Description	Value	Unit	Name
Time images and other products (except alerts) will be embargoed before release to the consortium (or	80	hour	L1EmbargoTMin

the public)			
Time images and other products (except alerts) will be embargoed before release to the consortium (or the public)	81	hour	L1EmbargoT

Derived from requirements:

OSS-REQ-0412: Level 1 Data Product Pixel Data Embargo in Operations

Impacted by LCR(s):

Added per LCR-3543

1.3.1.1.2 Level 1 Data Product Pixel Data Embargo in Commissioning

ID: DMS-REQ-0404 (Priority: 1a)

Specification: Rubin Observatory pixel data shall be held in a secure location and not released to the consortium prior to **L1CommissioningEmbargoT** after data acquisition during the Commissioning phase.

Specification: Certain images may be held longer at the discretion of the agencies.

Description	Value	Unit	Name
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Time images and other products (except alerts) will be embargoed before release to the consortium (or the public)	30	day	L1CommissioningEmbargoT
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Derived from requirements:

OSS-REQ-0413: Level 1 Data Product Pixel Data Embargo in Commissioning

Impacted by LCR(s):

Added per LCR-3543

1.3.1.2 Level 1 Data Product Availability for Solar System Objects

ID: DMS-REQ-0405 (Priority: 1b)

Specification: Solar System Objects shall be made publicly available within **L1PublicT** of successful moving source linkage and orbit computation.

Discussion: It takes multiple visits to the same Solar System Object in order to successfully link moving sources and compute their orbital parameters. As such, the time in which Solar System Objects can be made publicly available is dependent upon the time it takes to obtain these multiple visit images.

Description	Value	Unit	Name
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Maximum time from the acquisition of science data to the release of associated Level 1 Data Products (except alerts)	24	hour	L1PublicT
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Derived from requirements:

OSS-REQ-0415: Level 1 Data Product Availability for Solar System Objects

Impacted by LCR(s):

Added per LCR-3543

1.3.1.3 Level 1 Data Product Availability for Transient Alerts

ID: DMS-REQ-0406 (Priority: 1b)

Specification: Rubin Observatory shall support the distribution of at least **OTR1** % of alerts via the LSST alert distribution system within time **OTT1** from the conclusion of the camera's readout of the raw exposures used to generate each alert.

Discussion: **OTT1** includes a nominal time for alert transmission to multiple brokers, based only on outbound bandwidth from LSST, but any additional latency imposed by intermediate network hops, broker inbound bandwidth, or broker acceptance policy, is not.

Description	Value	Unit	Name
The latency of reporting optical transients following the completion of readout of the last image of a visit	1	minute	OTT1
Fraction of detectable alerts for which an alert is actually transmitted within latency OTT1 (see LSR-REQ-0101).	98	percent	OTR1

Derived from requirements:

OSS-REQ-0414: Level 1 Data Product Availability for Transient Alerts

Impacted by LCR(s):

Added per LCR-3543

1.3.2 Processed Visit Images

ID: DMS-REQ-0069 (Priority: 1a)

Specification: The DMS shall produce Processed Visit Images, in which the corresponding raw sensor array data has been trimmed of overscan and corrected for instrumental signature, including crosstalk. Images obtained in pairs during a standard visit are combined.

Discussion: Processed science exposures are not archived, and are retained for only a limited time to facilitate down-stream processing. They will be re-generated for users on-demand using the latest processing software and calibrations. This aspect of the processing for Special Programs data is specific to each program.

Derived from requirements:

OSS-REQ-0129: Exposures (Level 1)

OSS-REQ-0349: Data Release Production Crosstalk Correction

OSS-REQ-0328: Crosstalk Aggressor Limits

OSS-REQ-0348: Alert Production Crosstalk Correction

Impacted by LCR(s):

Updated per LCR-1923

1.3.2.1 Background Model Calculation

ID: DMS-REQ-0327 (Priority: 1b)

Specification: The DMS shall derive and persist a background model (both due to night sky and astrophysical) for each visit image, per CCD.

Derived from requirements:

OSS-REQ-0056: System Monitoring & Diagnostics

1.3.2.2 Generate Photometric Zeropoint for Visit Image

ID: DMS-REQ-0029 (Priority: 1b)

Specification: The DMS shall derive and persist a photometric zeropoint for each visit image, per CCD.

Derived from requirements:

DMS-REQ-0090: Generate Alerts

OSS-REQ-0056: System Monitoring & Diagnostics

OSS-REQ-0152: Level 1 Photometric Zero Point Error

1.3.2.3 Generate PSF for Visit Images

ID: DMS-REQ-0070 (Priority: 1b)

Specification: The DMS shall determine a characterization of the PSF for any specified location in Processed Visit Images.

Derived from requirements:

DMS-REQ-0116: Extended Object Shape Parameters

OSS-REQ-0056: System Monitoring & Diagnostics

1.3.2.4 Generate WCS for Visit Images

ID: DMS-REQ-0030 (Priority: 1a)

Specification: The DMS shall generate and persist a WCS for each visit image. The absolute accuracy of the WCS shall be at least **astrometricAccuracy** in all areas of the image, provided that there are at least **astrometricMinStandards** astrometric standards available in each CCD.

Discussion: The World Coordinate System for visits will be expressed in terms of a FITS Standard representation, which provides for named metadata to be interpreted as coefficients of one of a finite set of coordinate transformations.

Description	Value	Unit	Name
Absolute accuracy of the WCS across the focal plane (approximately one-quarter of a pixel).	50	milliarcsecond	astrometricAccuracy
Minimum number of astrometric standards per CCD.	5	integer	astrometricMinStandards

Derived from requirements:

DMS-REQ-0104: Produce Co-Added Exposures

DMS-REQ-0090: Generate Alerts

OSS-REQ-0162: Level 2 Catalog Accuracy

OSS-REQ-0149: Level 1 Catalog Precision

1.3.2.5 Documenting Image Characterization

ID: DMS-REQ-0328 (Priority: 1b)

Specification: The persisted format for Processed Visit Images shall be fully documented, and shall include a description of all image characterization data products.

Discussion: This will allow the community to use them to increase understanding of LSST images and derived LSST catalogs.

Derived from requirements:

OSS-REQ-0391: Data Product Conventions

1.3.2.6 Processed Visit Image Content

ID: DMS-REQ-0072 (Priority: 1a)

Specification: Processed visit images shall include the corrected science pixel array, an integer mask array where each bit-plane represents a logical statement about whether a particular detector pathology affects the pixel, a variance array which represents the expected variance in the corresponding science pixel, and a representation of the spatially varying PSF that applies over the extent of the science array. These images shall also contain metadata that map pixel to world (sky) coordinates (the WCS) as well as metadata from which photometric measurements can be derived.

Derived from requirements:

OSS-REQ-0129: Exposures (Level 1)

1.3.3 Difference Exposures

ID: DMS-REQ-0010 (Priority: 1b)

Specification: The DMS shall create a Difference Exposure from each Processed Visit Image by subtracting a re-projected, scaled, PSF-matched Template Image in the same passband.

Discussion: Difference Exposures are not archived, and are retained for only a limited time to facilitate Alert processing. They can be re-generated for users on-demand.

Derived from requirements:

OSS-REQ-0129: Exposures (Level 1)

DMS-REQ-0011: Produce Difference Sources

DMS-REQ-0033: Provide Source Detection Software

1.3.3.1 Difference Exposure Attributes

ID: DMS-REQ-0074 (Priority: 1b)

Specification: For each Difference Exposure, the DMS shall store: the identify of the input exposures and related provenance information, and a set of metadata attributes including at least a representation of the PSF matching kernel used in the differencing.

Derived from requirements:

OSS-REQ-0122: Provenance

1.3.4 Exposure Catalog

ID: DMS-REQ-0266 (Priority: 1a)

Specification: The DMS shall create an Exposure Catalog containing information for each exposure that includes the exposure date/time and duration, properties of the filter used, dome and telescope pointing and orientation, status of calibration apparatus, airmass and zenith distance, telescope and dome status, environmental information, and information regarding each sensor including an ID, its location in the focal plane, electronic configuration, and WCS.

Derived from requirements:

OSS-REQ-0130: Catalogs (Level 1)

1.3.5 DIASource Catalog

ID: DMS-REQ-0269 (Priority: 1b)

Specification: The DMS shall construct a catalog of all Sources detected on Difference Exposures with $\text{SNR} > \text{transSNR}$. For each Difference Source (DIASource), the DMS shall be able to provide the identity of the Difference Exposure from which it was derived; the identity of the associated SSObject, if any; the identity of the parent Source from which this DIASource has been deblended, if any. The DMS shall also measure and record a set of

attributes for each DIASource including at least: epoch of the observation, focal plane position centroid and error (pixel), sky position and associated error (radec), SNR of the detection; calibrated PS flux and associated error; likelihood of the observed data given the PS model; calibrated aperture flux and associated error; calibrated flux and associated error for a trailed source model, and length and angle of the trail; flux and associated parameters for a dipole model; parameters of an adaptive shape measurement and associated error; a measure of source extendedness; the estimated background at the position of the object in the template image with associated uncertainty; a measure of spuriousness; and flags indicating problems encountered while computing the aforementioned attributes. The DMS shall also determine and record measurements on the Calibrated exposure the following: calibrated flux and associated error for the source as measured on the Visit image.

Description	Value	Unit	Name
The signal-to-noise ratio in single-visit difference images above which all optical transients are to be reported.	5	float	transSNR

Derived from requirements:

OSS-REQ-0130: Catalogs (Level 1)

DMS-REQ-0270: Faint DIASource Measurements

1.3.6 Faint DIASource Measurements

ID: DMS-REQ-0270 (Priority: 2)

Specification: The DMS shall be able to measure and store DIASources fainter than **transSNR** that satisfy additional criteria. A limited number of such sources shall be made to enable monitoring of DIA quality.

Description	Value	Unit	Name
The signal-to-noise ratio in single-visit difference images above which all optical transients are to be reported.	5	float	transSNR

Derived from requirements:

OSS-REQ-0166: Alert Completeness and Purity

Impacted by LCR(s):

Updated per LCR-3543

1.3.7 Characterizing Variability

ID: DMS-REQ-0319 (Priority: 1b)

Specification: For alert production, DIAObject variability characterization shall include all

available data collected during the time period from the present to at least **diaCharacterizationCutoff** in the past.

Discussion: These measurements can come from the live L1 database. During the early part of the survey, the available data may span an interval less than **diaCharacterizationCutoff**. For difference image processing during Data Release Production, all data should be used for characterization.

Description	Value	Unit	Name
Time-period to use for characterizing variability in L1 system.	1	year	diaCharacterizationCutoff

Derived from requirements:

OSS-REQ-0126: Level 1 Data Products

Impacted by LCR(s):

Updated per LCR-3543

1.3.8 DIAObject Catalog

ID: DMS-REQ-0271 (Priority: 1b)

Specification: The DMS shall construct a catalog of all astrophysical objects identified

through difference image analysis (DIAObjects). The DIAObject entries shall include metadata attributes including at least: a unique identifier; the identifiers of the **diaNearbyObjMaxStar** nearest stars and **diaNearbyObjMaxGalaxy** nearest galaxies in the Object catalog lying within **diaNearbyObjRadius**, the probability that the DIAObject is the same as the nearby Object; and a set of DIAObject properties.

Description	Value	Unit	Name
Maximum number of nearby galaxies that can be associated with a DIASource.	3	integer	diaNearbyObjMaxGalaxy
Maximum number of stars that can be associated with a DIASource.	3	integer	diaNearbyObjMaxStar
Radius within which an Object is considered to be near, and possibly coincident with, the DIASource.	60	arcsecond	diaNearbyObjRadius

Derived from requirements:

OSS-REQ-0130: Catalogs (Level 1)

1.3.8.1 DIAObject Attributes

ID: DMS-REQ-0272 (Priority: 1b)

Specification: For each DIAObject the DMS shall store summary attributes including at least: sky position at the time of the observation; astrometric attributes including proper motion, parallax and related errors; point-source magnitude in each passband and related error; weighted mean forced-photometry flux and related error; periodic and non-periodic variability measures; and flags that encode special conditions encountered in measuring the above quantities.

Derived from requirements:

OSS-REQ-0130: Catalogs (Level 1)

1.3.9 SSObject Catalog

ID: DMS-REQ-0273 (Priority: 2)

Specification: The DMS shall produce a catalog of all Solar System Objects (SSObjects) that have been identified via Solar System Processing. The SSObject catalog shall include for each entry attributes including at least the following: Osculating orbital elements and associated uncertainties, minimum orbit intersection distance (MOID), mean absolute magnitude and slope parameter per band and associated errors, and flags that describe conditions of the description.

Discussion: The magnitude and angular velocity limits for identifying SSObjects are TBD. These limits may be driven more by computational resource constraints than by the raw reach of the collected data. The software may well be capable of exceeding the required limits, but at an unacceptable cost. The slope parameter will be poorly constrained until later in the survey. A baseline algorithm and acceptance criteria should be developed prior to

verification.

Derived from requirements:

OSS-REQ-0130: Catalogs (Level 1)

Impacted by LCR(s):

Updated per LCR-2376

1.3.10 Calculating SSOBJECT Parameters

ID: DMS-REQ-0323 (Priority: 3)

Specification: The LSST database shall supply functions or tables to provide, for every SSOBJECT, at least the phase angle for every observation, and the reduced and absolute asteroid magnitudes in all LSST bands.

Derived from requirements:

OSS-REQ-0126: Level 1 Data Products

Impacted by LCR(s):

Updated per LCR-2376

1.3.11 DIAFORCEDSOURCE Catalog

ID: DMS-REQ-0317 (Priority: 2)

Specification: The DMS shall create a DIAForcedSource Catalog, consisting of measured fluxes for entries in the DIAObject Catalog on Difference Exposures. Measurements for each forced-source shall include the DIAObject and visit IDs, the modeled flux and error (given fixed position, shape, and deblending parameters), and measurement quality flags.

Discussion: The large number of such forced sources makes it impractical to measure more attributes than are necessary to construct a light curve for variability studies.

Derived from requirements:

OSS-REQ-0130: Catalogs (Level 1)

1.3.12 Matching DIASources to Objects

ID: DMS-REQ-0324 (Priority: 1b)

Specification: A L1 DIASource to L2 Object positional cross-match table or database view shall be made available.

Discussion: Care should be taken to note that this is purely a cross-match based on separation on the sky and does not imply the DIASource and Object are physically the same.

Derived from requirements:

OSS-REQ-0126: Level 1 Data Products

1.3.13 Alert Content

ID: DMS-REQ-0274 (Priority: 1b)

Specification: The DMS shall create an Alert for each detected DIASource, to be broadcast using community protocols, with content that includes: a unique Alert ID, the Level-1 database ID, the DIASource record that triggered the alert, the DIAObject (or SSObject) record, 12 months of previous DIASource and SSSource records corresponding to the object (if available), and cut-outs of images (from the science, template, and difference images) of sufficient areal coverage to identify the DIASource and its immediate surroundings. These cutouts should include WCS, PSF, variance and mask information. The Alert should also include program and/or scheduler metadata.

Discussion: The aim for the Alert content is to include sufficient information to be relatively self-contained, and to minimize the demand for follow-up queries of the Level-1 database. This approach will likely increase the speed and efficiency of down-stream object classifiers. The included program and/or scheduler metadata should be sufficient to identify whether the image is associated with a Special Program (such as an in-progress Deep Drilling Field).

Derived from requirements:

OSS-REQ-0128: Alerts

Impacted by LCR(s):

Updated per LCR-3543

Updated per LCR-3831

1.3.14 Level 1 Data Quality Report Definition

ID: DMS-REQ-0097 (Priority: 1a)

Specification: The DMS shall produce a Level 1 Data Quality Report that contains indicators of data quality that result from running the DMS pipelines, including at least: Photometric zero point vs. time for each utilized filter; Sky brightness vs. time for each utilized filter; seeing vs. time for each utilized filter; PSF parameters vs. time for each utilized filter; detection efficiency for point sources vs. mag for each utilized filter.

Discussion: The seeing report is intended as a broad-brush measure of image quality. The PSF parameters provide more detail, as they include asymmetries and field location dependence.

Derived from requirements:

OSS-REQ-0131: Nightly Summary Products

DMS-REQ-0096: Generate Data Quality Report Within Specified Time

1.3.15 Level 1 Performance Report Definition

ID: DMS-REQ-0099 (Priority: 1b)

Specification: The DMS shall produce a Level 1 Performance Report that provides indicators of how the DMS has performed in processing the night's observations, including at least: number of observations successfully processed through each pipeline; number of observations for each pipeline that had recoverable failures (with a record of the failure type

and recovery mechanism); number of observations for each pipeline that had unrecoverable failures; number of observations archived at each DMS Facility; number of observations satisfying the science criteria for each active science program.

Derived from requirements:

OSS-REQ-0131: Nightly Summary Products

DMS-REQ-0098: Generate DMS Performance Report Within Specified Time

1.3.16 Level 1 Calibration Report Definition

ID: DMS-REQ-0101 (Priority: 1a)

Specification: The DMS shall produce a Level 1 Calibration Report that provides a summary of significant differences in Calibration Images that may indicate evolving problems with the telescope or camera, including a nightly broad-band flat in each filter.

Derived from requirements:

OSS-REQ-0131: Nightly Summary Products

DMS-REQ-0100: Generate Calibration Report Within Specified Time

1.3.17 Data Management Nightly Reporting

ID: DMS-REQ-0394 (Priority: 1a)

Specification: The LSST Data Management subsystem shall produce a searchable - interactive nightly report(s), from information published in the EFD by each subsystem,

summarizing performance and behavior over a user defined period of time (e.g. the previous 24 hours).

Derived from requirements:

OSS-REQ-0406: Subsystem Nightly Reporting

Impacted by LCR(s):

Added per LCR-1203

1.3.18 Regenerating L1 Data Products During Data Release Processing

ID: DMS-REQ-0325 (Priority: 2)

Specification: During Data Release Processing, all the Level 1 data products shall be regenerated using the current best algorithms.

Discussion: Variability characterization will use the full light curve history.

Derived from requirements:

OSS-REQ-0135: Uniformly calibrated and processed versions of Level 1 Data Products

1.3.19 Publishing predicted visit schedule

ID: DMS-REQ-0353 (Priority: 1b)

Specification: A service shall be provided to publish to the community the next visit location

and the predicted visit schedule provided by the OCS. This service shall consist of both a web page for human inspection and a web API to allow automated tools to respond promptly.

Discussion: The next visit and advanced schedule do not need to be published using the same service or protocol.

Derived from requirements:

OSS-REQ-0378: Advanced Publishing of Scheduler Sequence

1.4 Level 2 Data Products

1.4.1 Source Catalog

ID: DMS-REQ-0267 (Priority: 1b)

Specification: The DMS shall create a Catalog containing all Sources detected in single (standard) visits and will contain an identifier of the Exposure on which the Source was detected, as well as measurements of Source Attributes. The measured attributes (and associated errors) include location on the focal plane; a static point-source model fit to world coordinates and flux; a centroid and adaptive moments; and surface brightnesses through multiple circular apertures that are concentric, PSF-homogenized, and logarithmically spaced in intensity.

Derived from requirements:

OSS-REQ-0137: Catalogs (Level 2)

Impacted by LCR(s):

Updated per LCR-3293

Updated per LCR-3643

1.4.2 Object Catalog

ID: DMS-REQ-0275 (Priority: 1b)

Specification: The DMS shall create an Object Catalog, based on deblended sources detected in coadds and knowledge of DIASource, DIAObject, and SSObject Catalogs, after multi-epoch spatial association and characterization.

Derived from requirements:

OSS-REQ-0137: Catalogs (Level 2)

Impacted by LCR(s):

Updated per LCR-3293

1.4.2.1 Provide Photometric Redshifts of Galaxies

ID: DMS-REQ-0046 (Priority: 2)

Specification: The DMS shall compute a photometric redshift for all detected Objects.

Derived from requirements:

OSS-REQ-0133: Level 2 Data Products

1.4.2.2 Object Characterization

ID: DMS-REQ-0276 (Priority: 1b)

Specification: Each entry in the Object Catalog shall include the following characterization measures: a point-source model fit, a bulge-disk model fit, standard colors, a centroid, adaptive moments, Petrosian and Kron fluxes, surface brightness at multiple apertures, proper motion and parallax, and a variability characterization.

Discussion: These measurements are intended to enable LSST "static sky" science.

Derived from requirements:

OSS-REQ-0137: Catalogs (Level 2)

1.4.3 Associate Sources to Objects

ID: DMS-REQ-0034 (Priority: 1b)

Specification: The DMS shall associate Sources measured at different times and in different passbands with entries in the Object catalog.

Discussion: The task of association is to relate Sources from different times, filters, and sky positions, to the corresponding Objects. Having made these associations, further measurements can be made on the full object data to generate astronomically useful quantities.

Derived from requirements:

OSS-REQ-0339: Level 2 Source-Object Association Quality

DMS-REQ-0081: Produce Object Catalog

Impacted by LCR(s):

Updated per LCR-3643

1.4.4 Deep Detection Coadds

ID: DMS-REQ-0279 (Priority: 1b)

Specification: The DMS shall periodically create Co-added Images in each of the u, g, r, i, z, y passbands by combining all archived exposures taken of the same region of sky and in the same passband that meet specified quality conditions.

Discussion: Quality attributes may include thresholds on seeing, sky brightness, wavefront quality, PSF shape and spatial variability, or date of exposure.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

1.4.5 Template Coadds

ID: DMS-REQ-0280 (Priority: 1b)

Specification: The DMS shall periodically create Template Images in each of the u,g,r,i,z,y passbands. Templates may be constructed as part of executing the Data Release Production payload, or by a separate execution of the Template Generation payload. Prior to their availability from Data Releases these coadds shall be created incrementally when sufficient data passing relevant quality criteria is available.

Discussion: Image Templates are used by the Image Difference pipeline in the course of identifying transient or variable sources. The temporal range of epochs may be limited to avoid confusing slowly moving sources (such as high proper motion stars) with genuine transients. Incremental template building enables Alert Production when no Data Release template is yet available. It is anticipated that incremental template generation could be run nightly, but once a template is produced for a sky position and filter it will not be replaced until the next Data Release to avoid repeated baseline changes. To enable artifact rejection and to comply with OSS-REQ-0158, incremental templates will be built with at least three images.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

OSS-REQ-0158: Coaddition for Templates for Subtraction

Impacted by LCR(s):

Updated per LCR-2273

1.4.6 Multi-band Coadds

ID: DMS-REQ-0281 (Priority: 1b)

Specification: The DMS shall periodically create Multi-band Coadd images which are constructed similarly to Deep Detection Coadds, but where all passbands are combined.

Discussion: These coadds are not required to be persisted (c.f. DMS-REQ-0334) but software and services will be provided for their re-creation on demand by science users. These coadds satisfy the OSS-REQ-136 requirement for the multi-band version of "Detection co-adds for object detection, optimized for the faintest limiting magnitude", in addition to the per-band detection coadds from DMS-REQ-0279 (c.f. the "RGB coadds for visualization and EPO", DMS-REQ-0103).

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

Impacted by LCR(s):

Updated per LCR-2543

1.4.7 Best Seeing Coadds

ID: DMS-REQ-0330 (Priority: 2)

Specification: Best seeing coadds shall be made for each band (including multi-color).

Discussion: Note that DMS-REQ-0279 states that seeing-based input selection for co-adds should be possible. These coadds are not required to be persisted (c.f. DMS-REQ-0334) but software and services will be provided for their re-creation on demand by science users.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

Impacted by LCR(s):

Updated per LCR-2543

1.4.8 PSF-Matched Coadds

ID: DMS-REQ-0335 (Priority: 2)

Specification: PSF-matched coadds shall be made for each band (including multi-band).

Discussion: These are used to measure colors and shapes of objects at "standard" seeing. These coadds are not required to be persisted (c.f. DMS-REQ-0334) but software and services will be provided for their recreation on-demand by science users.

Derived from requirements:

OSS-REQ-0133: Level 2 Data Products

Impacted by LCR(s):

Updated per LCR-2543

1.4.9 Detecting faint variable objects

ID: DMS-REQ-0337 (Priority: 2)

Specification: The DMS shall be able to detect faint objects showing long-term variability, or nearby object with high proper motions.

Discussion: For example, this could be implemented using short-period (yearly) coadds.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

1.4.10 Targeted Coadds

ID: DMS-REQ-0338 (Priority: 2)

Specification: It shall be possible to retain small sections of all generated coadds.

Discussion: This supports quality assessment and targeted science.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

LSR-REQ-0040: Data Quality Monitoring

1.4.11 Coadd Image Method Constraints

ID: DMS-REQ-0278 (Priority: 1b)

Specification: Coadd Images shall be created by combining spatially overlapping Processed

Visit Images (on which bad pixels and transient sources have been masked), where the contributing Processed Visit Images have been re-projected to a common reference geometry, and matched to a common background level which best approximates the astrophysical background.

Discussion: It is expected that coadded images will be produced for all observed regions of the sky, not just the main survey area.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

1.4.12 Provide PSF for Coadded Images

ID: DMS-REQ-0047 (Priority: 1b)

Specification: The DMS shall determine a characterization of the PSF for any specified location in coadded images.

Discussion: The PSF model will be primarily used to perform initial object characterization and bootstrapping of multi-epoch object characterization (e.g., Multifit).

Derived from requirements:

DMS-REQ-0041: Measure Intrinsic Ellipticities of Small Galaxies

OSS-REQ-0153: World Coordinate System Accuracy

OSS-REQ-0316: Wavefront Sensor Data

OSS-REQ-0136: Co-added Exposures

1.4.13 Coadded Image Provenance

ID: DMS-REQ-0106 (Priority: 1b)

Specification: For each Coadded Image, DMS shall store: the list of input images and the pipeline parameters, including software versions, used to derive it, and a sufficient set of metadata attributes for users to re-create them in whole or in part.

Discussion: Not all coadded image types will be made available to end-users or retained for the life of the survey; however, sufficient metadata will be preserved so that they may be recreated by end-users.

Derived from requirements:

OSS-REQ-0122: Provenance

DMS-REQ-0104: Produce Co-Added Exposures

1.4.14 (Descoped) ~~Coadd Source Catalog~~

ID: ~~DMS-REQ-0277~~ (Priority: 1b)

Specification: ~~The DMS shall, in the course of creating the master Source Catalog, create a catalog from the coadds of all sources detected in each passband with a SNR > `coaddDetectThresh`.~~

Discussion: ~~CoaddSources are in general composites of overlapping astrophysical objects.~~

This catalog is an intermediate product in DR production, and will not be permanently archived nor released to end users.

Description	Value	Unit	Name
S/N threshold for detecting sources in Co-Add images for building the Source Catalog.	5	float	coaddDetectThresh

Impacted by LCR(s):

Descoped per LCR-3293

1.4.15 Detecting extended low surface brightness objects

ID: DMS-REQ-0349 (Priority: 2)

Specification: The DMS shall be able to detect extended low surface brightness objects in coadds.

Discussion: For example, this could be done by using the binned detection algorithm from SDSS.

Derived from requirements:

OSS-REQ-0133: Level 2 Data Products

Impacted by LCR(s):

Updated per LCR-3293

1.4.16 Forced-Source Catalog

ID: DMS-REQ-0268 (Priority: 1b)

Specification: The DMS shall create a Forced-Source Catalog, consisting of measured fluxes for all entries in the Object Catalog on all Processed Visit Images and Difference Images. Measurements for each forced-source shall include the object and visit IDs, the modelled flux and error (given fixed position, shape, and deblending parameters), and measurement quality flags.

Discussion: The large number of Forced Sources makes it impractical to measure more attributes than are necessary to construct a light curve for variability studies.

Derived from requirements:

OSS-REQ-0137: Catalogs (Level 2)

1.4.17 Tracking Characterization Changes Between Data Releases

ID: DMS-REQ-0339 (Priority: 2)

Specification: Small, overlapping, samples of data from older releases shall be kept loaded in the database.

Discussion: This enables a comparison of how current data releases relate to previous data releases and to improve data quality monitoring.

Derived from requirements:

LSR-REQ-0040: Data Quality Monitoring

Impacted by LCR(s):

Updated per LCR-3643

1.4.18 Produce Images for EPO

ID: DMS-REQ-0103 (Priority: 1b)

Specification: The DMS shall produce images for EPO purposes, according to the requirements in the DM-EPO ICD.

Discussion: This is expected to include polychromatic (e.g., RGB JPEG) images for casual users. The DM-EPO ICD is LSE-131.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

1.4.19 All-Sky Visualization of Data Releases

ID: DMS-REQ-0329 (Priority: 2)

Specification: Data Release Processing shall generate co-adds suitable for use in all-sky visualization tools, allowing panning and zooming of the entire data release.

Discussion: For example, this could mean HEALPix tiles suitable for use in a HiPS server. The exact technology choice has to be confirmed before understanding which format is required.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

1.4.19.1 Produce All-Sky HiPS Map

ID: DMS-REQ-0379 (Priority: 1b)

Specification: Data Release Production shall include the production of an all-sky image map for the existing coadded image area in each filter band, and at least one pre-defined all-sky color image map, following the IVOA HiPS Recommendation.

Discussion: The maximum resolution of the image maps is TBD; however, it would be desirable for it to be at least close to the underlying coadded image resolution, in order not to give a poor impression of the data quality. It is possible that the highest-resolution HiPS tiles could be provided on-demand from the LSST cutout service. It is expected that the HiPS tiles will be generated by resampling the existing coadds, not by performing an independent coaddition. This requires work from Science Pipelines on resolving the ambiguities in overlap regions. Whether the lower-resolution levels of the HiPS tiles will be generated by existing community tools (i.e., hipsgen) or by LSST code is also TBD. The color map being "pre-defined" means that the choice of bands will be made by the LSST Project as part of the

configuration of a Data Release. This does not preclude the Science Platform additionally providing means for interactive generation of other colorizations from the single-band HiPS maps.

By the terms of the HiPS Recommendation, a HiPS image map should include a corresponding MOC. This may or may not be the same as the MOCs for the survey envisioned under DMS-REQ-0383 elsewhere in this document, depending on choices made for data selection.

The Project should produce a technical note, during the construction era, detailing which of the optional components of the HiPS standard will be supported.

This requirement specifically calls for making HiPS maps from the standard coadds and therefore whatever policies are used for the inclusion of Special Programs data in the standard coadds will also automatically apply here. If there are both main-survey-depth and full-depth coadds for the deep drilling fields, then, it is a separate question as to whether HiPS maps will be generated for those fields.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

OSS-REQ-0391: Data Product Conventions

1.4.19.2 HiPS Service

ID: DMS-REQ-0380 (Priority: 1b)

Specification: The Data Management system shall include a secure and authenticated Internet endpoint for an IVOA-compliant HiPS service. This service shall be advertised via Registry as well as in the HiPS community mechanism operated by CDS, or whatever equivalent mechanism may exist in the LSST operations era.

Discussion: The DM HiPS service will be available only to data rights holders. LSST EPO will also operate a world-public HiPS service, but with its spatial resolution limited to approximately one arcsecond.

Derived from requirements:

OSS-REQ-0176: Data Access

1.4.19.3 HiPS Linkage to Coadds

ID: DMS-REQ-0381 (Priority: 2)

Specification: The HiPS maps produced by the Data Management system shall provide for straightforward linkage from the HiPS data to the underlying LSST coadded images. This SHOULD be implemented using a mechanism supported by both the LSST Science Platform and by community tools.

Discussion: It is intended that this be done using the "HiPS Progenitor" mechanism

introduced at the May 2018 IVOA meeting, or an evolution of it that emerges from the IVOA standardization process.

Derived from requirements:

OSS-REQ-0061: Data Visualization

OSS-REQ-0122: Provenance

1.4.19.4 HiPS Visualization

ID: DMS-REQ-0382 (Priority: 1b)

Specification: The LSST Science Platform shall support the visualization of the LSST-generated HiPS image maps as well as other HiPS maps which satisfy the IVOA HiPS Recommendation, and shall provide integrated behavior, such as the overplotting of catalog entries, comparable to that provided for individual source images (e.g., PVIs and coadd tiles).

Discussion: Further details will be provided in the LSST Science Platform Requirements, LDM-554.

Derived from requirements:

OSS-REQ-0061: Data Visualization

1.4.19.5 Produce MOC Maps

ID: DMS-REQ-0383 (Priority: 1b)

Specification: Data Release Production shall include the production of Multi-Order Coverage maps for the survey data, conformant with the IVOA MOC recommendation. A separate MOC shall be produced for each filter band for the main survey. Additional MOCs SHOULD be produced to represent special-programs datasets and other collections of on-sky data.

Discussion: It is likely to be useful to produce quite a large number of MOCs as part of releasing the data and documenting its quality. For example, it may be useful to produce both a MOC for all the data from a band and for only that part of the sky for which the SRD requirements in that band have been met. It also seems useful to produce MOCs for the deep drilling fields, etc. It may also be useful to produce MOCs on, for instance, a nightly basis, reflecting that part of the sky for which coverage was obtained in that night. The LSST project should engage in the work begun in 2018 on the development of standards and tools for *spatiotemporal* MOCs.

The tile resolution chosen for these MOCs should be fine enough to represent the dither pattern of the survey as well as the shape of the focal plane. Some testing should be done to determine a suitable scale.

The Project should produce a technical note, during the construction era, detailing the specific plans for creation of MOCs.

Derived from requirements:

OSS-REQ-0391: Data Product Conventions

OSS-REQ-0033: Survey Planning and Performance Monitoring

Impacted by LCR(s):

Updated per LCR-2008

1.4.19.6 Export MOCs As FITS

ID: DMS-REQ-0384 (Priority: 1b)

Specification: The Data Management system shall provide a means for exporting the LSST-generated MOCs in the FITS serialization form defined in the IVOA MOC Recommendation.

Discussion: The external endpoint for this should be designed to be conformant with relevant community practice and any IVOA standards that may emerge in this area.

Derived from requirements:

OSS-REQ-0391: Data Product Conventions

1.4.19.7 MOC Visualization

ID: DMS-REQ-0385 (Priority: 1b)

Specification: The LSST Science Platform shall support the visualization of the LSST-generated MOCs as well as other MOCs which satisfy the IVOA MOC Recommendation.

Discussion: We are considering the provision of services which allow computations based on MOCs, e.g., the use of a MOC from another mission or survey to define a query on the LSST data, but this is not ready for codification at this time.

Derived from requirements:

OSS-REQ-0061: Data Visualization

OSS-REQ-0033: Survey Planning and Performance Monitoring

Impacted by LCR(s):

Updated per LCR-2008

1.5 Calibration Data Products

1.5.1 Calibration Data Products

ID: DMS-REQ-0130 (Priority: 1a)

Specification: The DMS shall produce and archive Calibration Data Products that capture the signature of the telescope, camera and detector, including at least: Crosstalk correction matrix, Bias and Dark correction frames, a set of monochromatic dome flats spanning the wavelength range, a synthetic broad-band flat per filter, and an illumination correction frame per filter.

Derived from requirements:

DMS-REQ-0076: Keep Science Data Archive

OSS-REQ-0129: Exposures (Level 1)

OSS-REQ-0194: Calibration Exposures Per Day

OSS-REQ-0271: Supported Image Types

1.5.2 Calibration Image Provenance

ID: DMS-REQ-0132 (Priority: 1a)

Specification: For each Calibration Production data product, DMS shall record: the list of input exposures and the range of dates over which they were obtained; the processing parameters; the calibration products used to derive it; and a set of metadata attributes including at least: the date of creation; the calibration image type (e.g. dome flat, superflat, bias, etc); the provenance of the processing software; and the instrument configuration including the filter in use, if applicable.

Derived from requirements:

DMS-REQ-0130: Calibration Data Products

OSS-REQ-0122: Provenance

OSS-REQ-0123: Reproducibility

1.5.3 Bad Pixel Map

ID: DMS-REQ-0059 (Priority: 1a)

Specification: The DMS shall produce on an as-needed basis a map of detector pixels that are affected by one or more pathologies, such as non-responsive pixels, charge traps, and hot pixels. The particular pathologies shall be bit-encoded in, at least, 32-bit pixel values, so that additional pathologies may also be recorded in down-stream processing software.

Discussion: The fraction of bad pixels is expected to be small. Therefore the Reference Map,

while logically equivalent to an image, may be stored in a more compressible form.

Derived from requirements:

DMS-REQ-0058: Correct for Instrument Sensitivity Variation

OSS-REQ-0129: Exposures (Level 1)

OSS-REQ-0271: Supported Image Types

1.5.4 Bias Residual Image

ID: DMS-REQ-0060 (Priority: 1a)

Specification: The DMS shall construct on an as-needed basis an image that corrects for any temporally stable bias structure that remains after overscan correction. The Bias Residual shall be constructed from multiple, zero-second exposures where the overscan correction has been applied.

Derived from requirements:

DMS-REQ-0055: Correct for Camera Bias Structure

OSS-REQ-0271: Supported Image Types

OSS-REQ-0046: Calibration

1.5.5 Crosstalk Correction Matrix

ID: DMS-REQ-0061 (Priority: 1a)

Specification: The DMS shall, on an as-needed basis, determine from appropriate calibration

data what fraction of the signal detected in any given amplifier on each sensor in the focal plane appears in any other amplifier, and shall record that fraction in a correction matrix. The applicability of the correction matrix shall be verified in production processing on science data.

Discussion: The frequency with which the Cross-talk Correction Matrix must be computed will be determined during Commissioning and monitored during operations.

Derived from requirements:

OSS-REQ-0349: Data Release Production Crosstalk Correction

OSS-REQ-0329: Crosstalk Accuracy

OSS-REQ-0330: Crosstalk Measureability

Impacted by LCR(s):

Updated per LCR-1923

1.5.6 Dark Current Correction Frame

ID: DMS-REQ-0282 (Priority: 1a)

Specification: The DMS shall produce on an as-needed basis a dark current correction image, which is constructed from multiple, closed-shutter exposures of appropriate duration. The effectiveness of the Dark Correction shall be verified in production processing on science data.

Discussion: The need for a dark current correction will have to be quantified during

Commissioning. Collecting closed-dome dark exposures may be deemed necessary to monitor the health of the detectors, even if not used in calibration processing.

Derived from requirements:

OSS-REQ-0271: Supported Image Types

OSS-REQ-0046: Calibration

1.5.7 Monochromatic Flatfield Data Cube

ID: DMS-REQ-0063 (Priority: 1b)

Specification: The DMS shall produce on an as-needed basis an image that corrects for the color-dependent, pixel-to-pixel non-uniformity in the detector response. The images in the cube shall be constructed from exposures at multiple wavelengths of a uniformly illuminated source. The effectiveness of the flat-field shall be verified in production processing on science data.

Discussion: Monochromatic flat-fields are expected to be produced no more frequently than monthly, owing to the time required to obtain the exposures.

Derived from requirements:

DMS-REQ-0058: Correct for Instrument Sensitivity Variation

DMS-REQ-0057: Correct for Detector Fringing

OSS-REQ-0271: Supported Image Types

OSS-REQ-0046: Calibration

1.5.8 Illumination Correction Frame

ID: DMS-REQ-0062 (Priority: 1b)

Specification: The DMS shall produce on an as-needed basis an image that corrects for the non-uniform illumination of the flat-field calibration apparatus on the focal plane. The effectiveness of the Illumination Correction shall be verified in production processing on science data.

Discussion: The Illumination correction is anticipated to be quite stable. Updates to the correction should be no more frequent than monthly.

Derived from requirements:

DMS-REQ-0058: Correct for Instrument Sensitivity Variation

OSS-REQ-0271: Supported Image Types

OSS-REQ-0046: Calibration

1.5.9 Fringe Correction Frame

ID: DMS-REQ-0283 (Priority: 1b)

Specification: The DMS shall produce on an as-needed basis an image that corrects for detector fringing. The effectiveness of the Fringe Correction shall be verified in production processing on science data.

Discussion: Fringing is likely to affect only the reddest filters, where the CCD substrate

becomes semi-transparent to incident light.

Derived from requirements:

OSS-REQ-0271: Supported Image Types

OSS-REQ-0046: Calibration

1.6 Special Programs

1.6.1 Processing of Data From Special Programs

ID: DMS-REQ-0320 (Priority: 2)

Specification: It shall be possible for special programs to trigger their own data processing recipes, during the night instead of the nightly Alert Processing (but the recipes may still issue Alerts), or on alternative timescales.

Discussion: LSST will provide these recipes for processing Special Programs data when possible, which includes cases where DM can run original or reconfigured versions of existing pipelines, and excludes cases where the development of new algorithms, or the allocation of significant additional computational resources, are required. An example of an alternative timescale is a nightly trigger to coadd all the deep-drilling field images. Decisions about which recipes are applied to which Special Programs will be made by the Operations team, after consideration of the scientific goals, computational resources, and data rights policy.

Derived from requirements:

OSS-REQ-0392: Data Products Handling for Special Programs

Impacted by LCR(s):

Updated per LCR-2265

1.6.2 Prompt/DR Processing of Data from Special Programs

ID: DMS-REQ-0397 (Priority: 2)

Specification: It shall be possible for special programs data to be processed with the prompt- and/or annual-release pipelines alongside data from the main survey.

Discussion: The data from Special Programs should only be included in the prompt- and/or annual-release processing along with data from the wide-fast-deep main survey when it is (a) possible for DM to do so without additional effort and (b) beneficial to the LSST's main science objectives. Decisions about which data are included in the Prompt/DR processing pipelines are applied to which Special Programs will be made by the Operations team, after consideration of the scientific goals, computational resources, and data rights policy.

Derived from requirements:

OSS-REQ-0392: Data Products Handling for Special Programs

Impacted by LCR(s):

Updated per LCR-2265

1.6.3 Level 1 Processing of Special Programs Data

ID: DMS-REQ-0321 (Priority: 2)

Specification: All Level 1 processing from special programs shall be completed before data arrives from the following night's observations.

Discussion: Only Special Programs data that can be incorporated into the prompt pipeline (i.e., standard visit images, or non-standard visit images that can be shown to result in quality DIA products), will be processed with the prompt pipeline and contribute to the Alert Stream.

Derived from requirements:

OSS-REQ-0392: Data Products Handling for Special Programs

1.6.4 Constraints on Level 1 Special Program Products Generation

ID: DMS-REQ-0344 (Priority: 2)

Specification: The publishing of Level 1 data products from Special Programs shall be subject to the same performance requirements of the standard Level 1 system. In particular **L1PublicT** and **OTT1**.

Description	Value	Unit	Name
Maximum time from the acquisition of	24	hour	L1PublicT

science data to the release of associated Level 1 Data Products (except alerts)			
The latency of reporting optical transients following the completion of readout of the last image of a visit	1	minute	OTT1

Derived from requirements:

OSS-REQ-0392: Data Products Handling for Special Programs

1.6.5 Special Programs Database

ID: DMS-REQ-0322 (Priority: 1b)

Specification: Data products for special programs shall be stored in databases that are distinct from those used to store standard Level 1 and Level 2 data products. It shall be possible for these databases to be federated with the Level 1 and Level 2 databases to allow cross-queries and joins.

Derived from requirements:

OSS-REQ-0392: Data Products Handling for Special Programs

2 Productions

2.1 General Considerations

2.1.1 Query Repeatability

ID: DMS-REQ-0291 (Priority: 1b)

Specification: The DMS shall ensure that any query executed at a particular point in time against any DMS delivered database shall be repeatable at a later date, and produce results that are either identical or include additional results (owing to updates from Level-1 processing).

Discussion: It would be desirable to have the ability to "save" a query such that the date or data release would be included explicitly. Additionally, the ability to associate this query with a DOI would allow queries to be shared and included in scientific papers without requiring a large copy and paste.

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

2.1.2 Uniqueness of IDs Across Data Releases

ID: DMS-REQ-0292 (Priority: 1a)

Specification: To reduce the likelihood for confusion, all IDs shall be unique across

databases and database versions, other than those corresponding to uniquely identifiable entities (i.e., IDs of exposures).

Discussion: For example, DR4 and DR5 (or any other) release will share no identical Object, Source, DIAObject or DIASource IDs.

Derived from requirements:

OSS-REQ-0137: Catalogs (Level 2)

OSS-REQ-0130: Catalogs (Level 1)

2.1.3 Selection of Datasets

ID: DMS-REQ-0293 (Priority: 1a)

Specification: A Dataset may consist of one or more pixel images, a set of records in a file or database, or any other grouping of data that are processed or produced as a logical unit. The DMS shall be able to identify and retrieve complete, consistent datasets for processing.

Discussion: Logical groupings might be pairs of Exposures in a Visit, along with supporting metadata and provenance information, or might be groupings defined in the context of Level-3 processing.

Derived from requirements:

OSS-REQ-0118: Consistency and Completeness

OSS-REQ-0176: Data Access

2.1.4 Processing of Datasets

ID: DMS-REQ-0294 (Priority: 1b)

Specification: The DMS shall process all requested datasets until either a successful result is recorded or a permanent failure is recognized. If any dataset is processed, in part or in whole, more than once, only one of the wholly processed results will be recorded for further processing.

Discussion: The criteria may be specified by DMS processing software, or by a scientist end-user for Level-3 production.

Derived from requirements:

OSS-REQ-0117: Automated Production

OSS-REQ-0118: Consistency and Completeness

OSS-REQ-0119: Completeness

OSS-REQ-0120: Consistency

2.1.5 Transparent Data Access

ID: DMS-REQ-0295 (Priority: 2)

Specification: The DMS shall provide an interface that allows retrieval by productions or science users of datasets from any Facility where they may reside without requiring reconfiguration.

Derived from requirements:

OSS-REQ-0176: Data Access

2.2 Alert Production

2.2.1 Level-1 Production Completeness

ID: DMS-REQ-0284 (Priority: 1b)

Specification: The DMS shall ensure that all images taken by the camera and marked for Level-1 processing are eventually retrieved, archived, and processed even in the event of connectivity failure between downstream Facilities.

Derived from requirements:

OSS-REQ-0052: Summit Data Buffer

2.2.2 Calibration Images Available Within Specified Time

ID: DMS-REQ-0131 (Priority: 2)

Specification: Calibration products from a group of up to **nCalExpProc** related exposures that should be processed together, shall be available from the DMS image archive within **calProcTime** of the end of the acquisition of images/data for that group.

Discussion: The motivation here is that calibration images will be needed at least 1 hour prior to the start of observing and this requirement allows the calibration observations to be

planned accordingly.

Description	Value	Unit	Name
Time allowed to process nCalExpProc calibration exposures and have them available within the DMS.	1200	second	calProcTime
Maximum number of calibration exposures that can be processed together within time calProcTime .	25	integer	nCalExpProc

Derived from requirements:

DMS-REQ-0130: Calibration Data Products

OSS-REQ-0021: Base Site

OSS-REQ-0046: Calibration

OSS-REQ-0194: Calibration Exposures Per Day

2.2.3 Transient Alert Distribution

ID: DMS-REQ-0002 (Priority: 1b)

Specification: Identified transient events shall be made available to end-users in the form of alerts, which shall be published to community alert distribution networks using community-

standard protocols, to be determined during the LSST construction phase as community standards evolve.

Derived from requirements:

OSS-REQ-0127: Level 1 Data Product Availability

OSS-REQ-0184: Transient Alert Publication

2.2.3.1 Alert Stream Distribution

ID: DMS-REQ-0391 (Priority: 2)

Specification: LSST shall be capable of supporting the transmission of at least **numStreams** full alert streams out of the alert distribution system within **OTT1**.

Discussion: This requirement establishes the minimum capacity needed for timely transmission of alerts to community brokers.

Description	Value	Unit	Name
The minimum number of full streams that can be transmitted out of the alert distribution system.	5	integer	numStreams
The latency of reporting optical transients following the completion of	1	minute	OTT1

readout of the last image of a visit			
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Derived from requirements:

OSS-REQ-0184: Transient Alert Publication

OSS-REQ-0127: Level 1 Data Product Availability

Impacted by LCR(s):

Added per LCR-1883

2.2.3.2 Alert Delay and Failure Tolerances

ID: DMS-REQ-0392 (Priority: 2)

Specification: The system shall reliably produce alerts for standard science visits read out in the camera [and specified to be analyzed by Data Management] such that no more than **sciVisitAlertDelay** per cent of visits will fail to have at least **OTR1** per cent of its alerts distributed via the LSST alert distribution system within **OTT1**, and no more than **sciVisitAlertFailure** per cent of visits will fail to generate and distribute alerts (integrated over all stages of data handling)

Discussion: As with DMS-REQ-0004, this specification applies to visits which should have resulted in fewer than **nAlertVisitPeak**.

Description	Value	Unit	Name
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The latency of reporting optical transients following the completion of readout of the last image of a visit	1	minute	OTT1
The instantaneous peak number of alerts per standard visit.	40000	integer	nAlertVisitPeak
Maximum fraction of visits for which alerts are not generated or distributed.	0.1	percent	sciVisitAlertFailure
Fraction of detectable alerts for which an alert is actually transmitted within latency OTT1 (see LSR-REQ-0101).	98	percent	OTR1
Maximum fraction of science visits with less than OTR1 percent of the alerts distributed within OTT1 .	1	percent	sciVisitAlertDelay

Derived from requirements:

OSS-REQ-0112: Science Visit Alert Generation Reliability

Impacted by LCR(s):

Added per LCR-1883

2.2.3.3 Performance Requirements for Transient Alert Distribution

ID: DMS-REQ-0393 (Priority: 2)

Specification: The system shall be able to identify and distribute an average of at least **nAlertVisitAvg** alerts per standard visit during a given night, and at least **nAlertVisitPeak** for a single standard visit.

Specification: Performance shall degrade gracefully beyond **nAlertVisitAvg**.

Discussion: The term 'degrade gracefully' means that visits with an excess of difference-image sources should not cause any DMS downtime; i.e., the system does not crash and is able to distribute alerts from that visit, potentially with greater latency.

Description	Value	Unit	Name
The instantaneous peak number of alerts per standard visit.	40000	integer	nAlertVisitPeak
The nightly minimum average number of alerts per standard visit.	10000	integer	nAlertVisitAvg

Derived from requirements:

LSR-REQ-0101: Data Processing for Single Visits and Transients

OSS-REQ-0193: Alerts per Visit

Impacted by LCR(s):

Added per LCR-1883

2.2.4 Alert Filtering Service

ID: DMS-REQ-0342 (Priority: 2)

Specification: A basic, limited capacity, alert filtering service shall be provided that can be given user defined filters to reduce the alert stream to manageable levels.

Derived from requirements:

LSR-REQ-0025: Transient Filtering

2.2.4.1 Pre-defined alert filters

ID: DMS-REQ-0348 (Priority: 2)

Specification: Users of the LSST Alert Filtering Service shall be able to use a predefined set of simple filters.

Discussion: See LSR-REQ-0026

Derived from requirements:

LSR-REQ-0026: Predefined Transient Filters

2.2.4.2 Performance Requirements for LSST Alert Filtering Service

ID: DMS-REQ-0343 (Priority: 2)

Specification: The LSST alert filtering service shall support **numBrokerUsers** simultaneous users with each user allocated a bandwidth capable of receiving the equivalent of **numBrokerAlerts** alerts per visit.

Discussion: The constraint on number of alerts is specified for the full VOEvent alert content, but could also be satisfied by all alerts being received with minimal alert content.

Description	Value	Unit	Name
Number of full-sized alerts that can be received per visit per user.	20	integer	numBrokerAlerts
Supported number of simultaneous users connected to the LSST alert filtering system.	100	integer	numBrokerUsers

Derived from requirements:

OSS-REQ-0184: Transient Alert Publication

OSS-REQ-0193: Alerts per Visit

2.2.5 Level 1 Source Association

ID: DMS-REQ-0285 (Priority: 1b)

Specification: The DMS shall associate clusters of DIASources detected on multiple visits taken at different times with either a DIAObject or an SSObject.

Discussion: The association will represent the underlying astrophysical phenomenon.

Derived from requirements:

OSS-REQ-0159: Level 1 Solar System Object Quality

OSS-REQ-0160: Level 1 Difference Source - Difference Object Association Quality

OSS-REQ-0130: Catalogs (Level 1)

2.2.6 SSObject Precovery

ID: DMS-REQ-0286 (Priority: 2)

Specification: Upon identifying a new SSObject, the DMS shall associate additional DIAObjects that are consistent with the orbital parameters (precovery), and update DIAObject entries so associated.

Derived from requirements:

OSS-REQ-0159: Level 1 Solar System Object Quality

2.2.7 DIASource Precovery

ID: DMS-REQ-0287 (Priority: 1b)

Specification: For all DIASources not associated with either DIAObjects or SSObjects, the DMS shall perform forced photometry at the location of the new source (precovery) on all Difference Exposures obtained in the prior **precoveryWindow**, and make the results publicly available within **L1PublicT**.

Discussion: The **precoveryWindow** is intended to satisfy the most common scientific use cases (e.g., Supernovae), without placing an undue burden on the processing infrastructure. For reasons of practicality and efficiency, **precoveryWindow** \leq **l1CacheLifetime**.

Description	Value	Unit	Name
Maximum look-back time for precovery measurements on prior Exposures.	30	day	precoveryWindow
Maximum time from the acquisition of science data to the release of associated Level 1 Data Products (except alerts)	24	hour	L1PublicT
Lifetime in the cache of un-archived Level-1 data products.	30	day	l1CacheLifetime

Derived from requirements:

OSS-REQ-0130: Catalogs (Level 1)

2.2.8 Use of External Orbit Catalogs

ID: DMS-REQ-0288 (Priority: 2)

Specification: It shall be possible for DMS to make use of approved external catalogs and observations to improve the identification of SSO objects, and therefore increase the purity of the transient Alert stream in nightly processing.

Derived from requirements:

OSS-REQ-0159: Level 1 Solar System Object Quality

2.2.9 Solar System Objects Available Within Specified Time

ID: DMS-REQ-0089 (Priority: 1b)

Specification: Observed Solar System objects and associated metadata shall be available for public access in the DMS science data archive within time **L1PublicT** of their generation by the DMS.

Derived from requirements:

DMS-REQ-0004: Level 1 Data Product Availability

DMS-REQ-0086: Produce Orbit Catalog

OSS-REQ-0127: Level 1 Data Product Availability

Impacted by LCR(s):

Updated per LCR-2376

2.2.10 Generate Data Quality Report Within Specified Time

ID: DMS-REQ-0096 (Priority: 1a)

Specification: The DMS shall generate a nightly Data Quality Report within time **dqReportComplTime** in both human-readable and machine-readable forms.

Discussion: The Report must be timely in order to evaluate whether changes to hardware, software, or procedures are needed for the following night's observing.

Description	Value	Unit	Name
Latency for producing Level 1 Data Quality Report.	4	hour	dqReportCompl Time

Derived from requirements:

OSS-REQ-0131: Nightly Summary Products

2.2.11 Generate DMS Performance Report Within Specified Time

ID: DMS-REQ-0098 (Priority: 1b)

Specification: The DMS shall generate a nightly DMS Performance Report within time **perfReportComplTime** in both human-readable and machine-readable forms.

Discussion: The Report must be timely in order to evaluate whether changes to hardware, software, or procedures are needed for the following night's observing.

Description	Value	Unit	Name
Latency for producing Level 1 DMS Performance Report.	4	hour	perfReportComplTime

Derived from requirements:

OSS-REQ-0131: Nightly Summary Products

2.2.12 Generate Calibration Report Within Specified Time

ID: DMS-REQ-0100 (Priority: 1b)

Specification: The DMS shall generate a nightly Calibration Report within time **calibReportComplTime** in both human-readable and machine-readable forms.

Discussion: The Report must be timely in order to evaluate whether changes to hardware, software, or procedures are needed for the following night's observing.

Description	Value	Unit	Name
Latency for producing Level 1 Calibration Report.	4	hour	calibReportCom plTime

Derived from requirements:

OSS-REQ-0131: Nightly Summary Products

2.3 Calibration Production

2.3.1 Calibration Production Processing

ID: DMS-REQ-0289 (Priority: 1a)

Specification: The DMS shall be capable of producing calibration data products on an as-needed basis, consistent with monitoring the health and performance of the instrument, the availability of raw calibration exposures, the temporal stability of the calibrations, and of the SRD requirements for calibration accuracy.

Derived from requirements:

OSS-REQ-0170: Calibration Data

OSS-REQ-0004: The Archive Facility

2.4 Data Release Production

2.4.1 ~~(Descoped) Timely Publication of Level 2 Data Releases~~

ID: ~~DMS-REQ-0006 (Priority: 1b)~~

Specification: ~~The DMS shall make available to end-users all Level 2 data products as soon as possible following the execution of the Data Release Production and the verification of science data quality.~~

Derived from requirements:

~~DMS-REQ-0005: Produce Data Releases~~

~~OSS-REQ-0134: Level 2 Data Product Availability~~

Impacted by LCR(s):

~~Descoped per LCR-962~~

2.4.2 Associating Objects across data releases

ID: DMS-REQ-0350 (Priority: 2)

Specification: It shall be possible to associate an Object in one data release to the most likely match in the Object table from another data release. This shall be possible without the previous data releases being online.

Discussion: This could be done with a database table mapping every Object in one data

release to the matched Object in every other data release.

2.5 Level 3 Production

2.5.1 Access Controls of Level 3 Data Products

ID: DMS-REQ-0340 (Priority: 2)

Specification: All Level 3 data products shall be configured to have the ability to have access restricted to the owner, a list of people, a named group, or be completely public.

Discussion: These features are supported by VOSpace.

Derived from requirements:

OSS-REQ-0142: Access

OSS-REQ-0176: Data Access

OSS-REQ-0187: Information Security

2.5.2 Level 3 Data Import

ID: DMS-REQ-0290 (Priority: 2)

Specification: The DMS shall be able to ingest tables from common file formats (e.g. FITS tables, CSV files with supporting metadata) to facilitate the loading of external catalogs and the production of Level-3 data products.

Derived from requirements:

OSS-REQ-0140: Production

2.5.3 Level 3 Resource Allocation Mechanism

ID: DMS-REQ-0119 (Priority: 2)

Specification: The DMS shall provide a resource allocation mechanism for the DACs that allows the prioritization and allocation of the resources defined in DMS-REQ-0396 to a variety of Level 3 processing and storage activities based on user identity and group membership.

Discussion: It is assumed that the DAC Level 3 processing resources will likely be oversubscribed, making this necessary. This technical mechanism is intended to be used to implement the decisions made by an anticipated administrative mechanism in the operations organization, such as an allocation committee.

Derived from requirements:

OSS-REQ-0143: Resource Allocation

Impacted by LCR(s):

Updated per LCR-2243

2.5.4 Level 3 Data Product Self Consistency

ID: DMS-REQ-0120 (Priority: 2)

Specification: The DMS shall provide a means for ensuring that users' Level 3 processing tasks can be carried out on self-consistent inputs - i.e., catalogs, images, metadata, calibrations, camera configuration data, etc., that match each other and all arise from consistent Level 1 and Level 2 processings.

Derived from requirements:

OSS-REQ-0120: Consistency

OSS-REQ-0118: Consistency and Completeness

2.5.5 Provenance for Level 3 processing at DACs

ID: DMS-REQ-0121 (Priority: 2)

Specification: The DMS shall provide a means for recording provenance information for Level 3 processing that is performed at DACs, covering at least all the DMS-provided inputs to the processing (e.g., catalog data used as inputs, dataset metadata, calibrations and camera data from the EFD).

Discussion: The DMS should also provide an optional means for Level 3 processing users at DACs to maintain basic provenance information on their own inputs to a processing task, such as code or additional calibration data. **Rationale:** the DMS should facilitate Level 3 processing users in being able to carry out their work in a reproducible way.

Derived from requirements:

OSS-REQ-0122: Provenance

2.5.6 Software framework for Level 3 catalog processing

ID: DMS-REQ-0125 (Priority: 2)

Specification: The DMS shall provide a software framework that facilitates Level 3 processing of catalogs. This framework shall provide a means for applying user-provided processing to catalog data, including measuring and ensuring the completeness of the application - i.e., that the specified processing was applied to all of, and only, the entire contents of the desired catalog(s).

Derived from requirements:

DMS-REQ-0120: Level 3 Data Product Self Consistency

OSS-REQ-0121: Open Source, Open Configuration

OSS-REQ-0122: Provenance

2.5.7 Software framework for Level 3 image processing

ID: DMS-REQ-0128 (Priority: 2)

Specification: The DMS shall provide a software framework that facilitates Level 3 processing of image data. This framework shall provide a means for applying user-provided processing to image data, including measuring and ensuring the completeness of the application - i.e., that the specified processing was applied to all of, and only, the entire contents of the desired dataset.

Derived from requirements:

DMS-REQ-0120: Level 3 Data Product Self Consistency

OSS-REQ-0121: Open Source, Open Configuration

OSS-REQ-0122: Provenance

3 Software

3.1 General Considerations

3.1.1 Software Architecture to Enable Community Re-Use

ID: DMS-REQ-0308 (Priority: 1b)

Specification: The DMS software architecture shall be designed to enable high throughput on high-performance compute platforms, while also enabling the use of science-specific algorithms by science users on commodity desktop compute platforms.

Discussion: The high data volume and short processing timeline for LSST Productions anticipates the use of high-performance compute infrastructure, while the need to make the science algorithms immediately applicable to science teams for Level-3 processing drives the need for easy interoperability with desktop compute environments.

Derived from requirements:

OSS-REQ-0121: Open Source, Open Configuration

3.1.2 Reproducibility

The following requirements define what it means for the LSST data management system to ensure that the results of data processing are reproducible.

3.1.2.1 *Provide Re-Run Tools*

ID: DMS-REQ-0388 (Priority: 1b)

Specification: The Data Management System shall provide tools to re-run a data processing operation under the same conditions as a previous run of that operation, based on provenance data recorded by the system.

Discussion: The "conditions" include the LSST software, its configuration parameters, and support data such as calibration frames.

Derived from requirements:

OSS-REQ-0123: Reproducibility

OSS-REQ-0172: Provenance Archiving

OSS-REQ-0122: Provenance

3.1.2.2 *Re-Runs on Similar Systems*

ID: DMS-REQ-0389 (Priority: 1b)

Specification: A re-run based on provenance, if run on the same system or a system with identically configured hardware and system software, shall produce the same results (with the exception of provenance data or other execution records that depend on the wall-clock time or on variable system loads).

Discussion: "System software" refers to the substrate of operating systems, device drivers, language standard libraries, and the like, not to the higher-level software written by LSST or imported into the LSST code base; the latter are constrained by DMS-REQ-0388 to be the same for a provenance-based re-run.

Derived from requirements:

OSS-REQ-0172: Provenance Archiving

OSS-REQ-0123: Reproducibility

OSS-REQ-0169: Data Products

OSS-REQ-0122: Provenance

3.1.2.3 Re-Runs on Other Systems

ID: DMS-REQ-0390 (Priority: 1b)

Specification: A re-run based on provenance, if run on a different system (but whose configuration still meets established LSST requirements), shall produce results which are the same to the extent computationally feasible (with the exception of provenance data or other execution records that depend on the wall-clock time or on variable system loads).

Discussion: "To the extent computationally feasible" refers primarily to the possibility that different implementations of the IEEE floating-point standards may produce different results in the least significant figures, and that under some circumstances these variations can be amplified by algorithms and by choices made by optimizing compilers. It is expected that normal "best practices" for writing floating point code will be followed to minimize the effects of these hardware differences, but they cannot be avoided altogether.

Derived from requirements:

OSS-REQ-0169: Data Products

OSS-REQ-0172: Provenance Archiving

OSS-REQ-0123: Reproducibility

OSS-REQ-0122: Provenance

3.2 Applications Software

3.2.1 Simulated Data

ID: DMS-REQ-0009 (Priority: 1b)

Specification: The DMS shall provide the ability to inject artificial or simulated data into data products to assess the functional and temporal performance of the production processing software.

Derived from requirements:

DMS-REQ-0007: Pipeline Infrastructure

OSS-REQ-0351: Difference Source Spurious Probability Metric

OSS-REQ-0353: Difference Source Spuriousness Threshold - Transients

OSS-REQ-0354: Difference Source Spuriousness Threshold - MOPS

3.2.2 Pre-cursor, and Real Data

ID: DMS-REQ-0296 (Priority: 1a)

Specification: The DMS shall provide for the ability to process data from other electronic, pixel-oriented astronomical imaging cameras.

Discussion: A comparison of DMS products to that produced by similar systems for other cameras provides an essential validation of DMS algorithms and techniques.

3.2.3 Image Differencing

ID: DMS-REQ-0032 (Priority: 1b)

Specification: The DMS shall provide software to perform image differencing, generating Difference Exposures from the comparison of single exposures and/or coadded images.

Derived from requirements:

OSS-REQ-0121: Open Source, Open Configuration

OSS-REQ-0129: Exposures (Level 1)

3.2.4 Provide Source Detection Software

ID: DMS-REQ-0033 (Priority: 1a)

Specification: The DMS shall provide software for the detection of sources in a calibrated image, which may be a Difference Image or a Co-Add image.

Derived from requirements:

DMS-REQ-0080: Difference Sources Available within 24 hours

OSS-REQ-0121: Open Source, Open Configuration

OSS-REQ-0130: Catalogs (Level 1)

OSS-REQ-0137: Catalogs (Level 2)

3.2.5 Provide Calibrated Photometry

ID: DMS-REQ-0043 (Priority: 1a)

Specification: The DMS shall provide calibrated photometry in each observed passband for all measured entities (e.g., DIASources, Sources, Objects), measuring the AB magnitude of the equivalent flat-SED source, above the atmosphere. Fluxes shall be calculated for all measured entities.

Discussion: Note that the SED is only assumed to be flat within the passband of the measurement.

Derived from requirements:

OSS-REQ-0137: Catalogs (Level 2)

OSS-REQ-0130: Catalogs (Level 1)

OSS-REQ-0275: Calibration Processing Performance Allocations

Impacted by LCR(s):

Updated per LCR-2378

3.2.6 Provide Astrometric Model

ID: DMS-REQ-0042 (Priority: 1b)

Specification: An astrometric model shall be provided for every Object and DIAObject which specifies at least the proper motion and parallax, and the estimated uncertainties on these quantities.

Derived from requirements:

OSS-REQ-0149: Level 1 Catalog Precision

OSS-REQ-0153: World Coordinate System Accuracy

OSS-REQ-0160: Level 1 Difference Source - Difference Object Association Quality

OSS-REQ-0162: Level 2 Catalog Accuracy

3.2.7 Provide Beam Projector Coordinate Calculation Software

ID: DMS-REQ-0351 (Priority: 1a)

Specification: The DMS shall provide software to represent the coordinate transformations relating the collimated beam projector position and telescope pupil position to the illumination position on the telescope optical elements and focal plane.

Derived from requirements:

OSS-REQ-0383: Beam Projector Coordinate Relationship

3.2.8 Enable a Range of Shape Measurement Approaches

ID: DMS-REQ-0052 (Priority: 1b)

Specification: The DMS shall provide for the use of a variety of shape models on multiple kinds of input data to measure sources: measurement on coadds; measurement on coadds using information (e.g., PSFs) extracted from the individual exposures; measurement based on all the information from the individual Exposures simultaneously.

Discussion: The most appropriate measurement model to apply depends upon the nature of the composite source.

Derived from requirements:

OSS-REQ-0137: Catalogs (Level 2)

3.2.9 Provide User Interface Services

ID: DMS-REQ-0160 (Priority: 1b)

Specification: The DMS shall provide software for User Interface Services, including services to: browse LSST data products through astronomical views or visualizations; create and serve "best" images of selectable regions of the sky; resample and re-project images, and visualize catalog content.

Derived from requirements:

OSS-REQ-0057: Image Visualization

3.3 Middleware Software

3.3.1 DMS Initialization Component

ID: DMS-REQ-0297 (Priority: 1a)

Specification: The DMS shall contain a component that, at each Center, can initialize the DM Subsystem into a well-defined safe state when powered up.

Discussion: A safe state is one that does not permit the corruption or loss of previously archived data, nor of sending spurious information over any interface.

Derived from requirements:

OSS-REQ-0041: Subsystem Activation

OSS-REQ-0307: Subsystem Initialization

OSS-REQ-0121: Open Source, Open Configuration

OSS-REQ-0122: Provenance

3.3.2 Provide Data Access Services

ID: DMS-REQ-0155 (Priority: 1a)

(This is a composite requirement in the SysML model, which simply aggregates its children.)

Derived from requirements:

OSS-REQ-0176: Data Access

3.3.2.1 Data Product Ingest

ID: DMS-REQ-0299 (Priority: 1a)

Specification: The DMS shall provide software to ingest data products into the Science Data Archive.

Derived from requirements:

OSS-REQ-0141: Storage

OSS-REQ-0004: The Archive Facility

3.3.2.2 Data Product and Raw Data Access

ID: DMS-REQ-0298 (Priority: 1a)

Specification: The DMS shall provide software for Data Access Services to list and retrieve image, file, and catalog data products (including raw telescope images and calibration data), their associated metadata, their provenance, or any combination thereof, independent of their actual storage location.

Derived from requirements:

OSS-REQ-0176: Data Access

3.3.2.3 Bulk Download Service

ID: DMS-REQ-0300 (Priority: 1b)

Specification: The DMS shall provide software to enable bulk download of data products and raw data, subject to network bandwidth.

Discussion: This includes bulk download of older data releases.

Derived from requirements:

OSS-REQ-0178: Data Distribution

3.3.3 Provide Image Access Services

ID: DMS-REQ-0065 (Priority: 1b)

Specification: The DMS shall provide a service for Image Access through community data access protocols, to support programmatic search and retrieval of images or image cut-outs. The service shall support one or more community standard formats, including the LSST pipeline input format.

Discussion: At least the FITS image format will be supported through an IVOA-standard service such as SIAP. Other image formats such as JPG may be more compatible with education/public outreach needs.

Derived from requirements:

OSS-REQ-0180: Data Products Query and Download Availability

OSS-REQ-0181: Data Products Query and Download Infrastructure

OSS-REQ-0176: Data Access

3.3.4 Control of Level-1 Production

ID: DMS-REQ-0301 (Priority: 1b)

Specification: The DMS shall contain a component to control all Level-1 Data Product production.

Discussion: This specifically addresses the need to control the Alert Production across all DMS facilities.

Derived from requirements:

OSS-REQ-0044: Standard Operating States

3.3.5 Provide Pipeline Execution Services

ID: DMS-REQ-0156 (Priority: 1a)

(This is a composite requirement in the SysML model, which simply aggregates its children.)

Derived from requirements:

OSS-REQ-0037: Observatory Control System Definition

OSS-REQ-0117: Automated Production

3.3.5.1 Production Orchestration

ID: DMS-REQ-0302 (Priority: 1a)

Specification: The DMS shall provide software to orchestrate execution of productions, including deploying pipelines on a computing platform.

Derived from requirements:

OSS-REQ-0004: The Archive Facility

OSS-REQ-0038: Scope of Control

OSS-REQ-0117: Automated Production

3.3.5.2 Production Monitoring

ID: DMS-REQ-0303 (Priority: 1a)

Specification: The DMS shall provide software to monitor execution of pipelines in real time.

Derived from requirements:

OSS-REQ-0004: The Archive Facility

OSS-REQ-0038: Scope of Control

OSS-REQ-0034: System Control

3.3.5.3 Production Fault Tolerance

ID: DMS-REQ-0304 (Priority: 1a)

Specification: The DMS shall provide software to detect faults in pipeline execution and recover when possible.

Derived from requirements:

OSS-REQ-0117: Automated Production

3.3.6 Provide Pipeline Construction Services

ID: DMS-REQ-0158 (Priority: 1a)

(This is a composite requirement in the SysML model, which simply aggregates its children.)

3.3.6.1 Task Configuration

ID: DMS-REQ-0306 (Priority: 1a)

Specification: The DMS shall provide software to define, override components of, and verify the suitability of the configuration for a task.

Derived from requirements:

OSS-REQ-0121: Open Source, Open Configuration

OSS-REQ-0122: Provenance

3.3.6.2 Task Specification

ID: DMS-REQ-0305 (Priority: 1a)

Specification: The DMS shall provide software to define (and redefine without recompilation) a pipeline task containing a science algorithm, which may in turn consist of the execution of other subtasks.

Derived from requirements:

OSS-REQ-0121: Open Source, Open Configuration

OSS-REQ-0122: Provenance

3.3.7 Unique Processing Coverage

ID: DMS-REQ-0307 (Priority: 2)

Specification: The DMS shall enable applications to process every record in a table meeting user-specified criteria exactly once.

Commentary: The "exactly once" constraint can be confusing to some readers and would benefit from clarification in the discussion.

Derived from requirements:

OSS-REQ-0120: Consistency

OSS-REQ-0118: Consistency and Completeness

4 Facilities

4.1 Data Archive

4.1.1 Science Data Archive

ID: DMS-REQ-0003 (Priority: 1a)

Specification: The DMS shall create an archive for all its public data products and the raw data necessary to reproduce them, scalable to the data from the full survey and all Data Releases.

Discussion: Access to the archive is treated separately. The wording "scalable" is used because the construction project is not required to provision the archive for the entire survey.

Derived from requirements:

OSS-REQ-0167: Data Archiving

Impacted by LCR(s):

Added per LCR-2543

4.1.1.1 Ancillary Data Archiving

ID: DMS-REQ-0398 (Priority: 1b)

Specification: The Science Data Archive shall contain all necessary engineering and calibration data for the full understanding of the performance and operation of the Observatory.

Impacted by LCR(s):

Added per LCR-2543

Updated per LCR-3643

4.1.2 Engineering & Facility Database Archive

ID: DMS-REQ-0102 (Priority: 1a)

Specification: Engineering and Facility data from the Observatory Control System and associated metadata shall be permanently archived by the DMS and available for public access within **L1PublicT** hours of their generation by the OCS.

Description	Value	Unit	Name
Maximum time from the acquisition of science data to the release of associated Level 1 Data Products (except alerts)	24	hour	L1PublicT

Derived from requirements:

OSS-REQ-0132: Engineering and Facility Database Archive

DMS-REQ-0398: Ancillary Data Archiving

Impacted by LCR(s):

Updated per LCR-2543

4.1.3 Archive Camera Test Data

ID: DMS-REQ-0372 (Priority: 1a)

Specification: The DMS shall be able to archive a designated subset of Camera test data and make it available in an environment matching the data backbone interfaces.

Discussion: This requirement describes a capability needed primarily in construction.

Impacted by LCR(s):

Updated per LCR-2543

4.1.4 Raw Data Archiving Reliability

ID: DMS-REQ-0309 (Priority: 1a)

Specification: The DMS system shall archive all data, including science, wavefront, and guider images and associated metadata, that are presented for archiving by up-stream

systems, with a rate of permanent data loss or corruption not to exceed **dataLossMax**.

Discussion: Data "presented for archiving" means data that have been successfully transferred from upstream systems to DMS, and that are intended for permanent archiving. Data obtained for diagnostic and other limited-use engineering purposes are specifically excluded from this requirement.

Description	Value	Unit	Name
Maximum fraction of raw images that are permitted to be permanently lost or corrupted, including the loss or corruption of essential associated metadata, once acquired by the DMS.	1.0e-5	float	dataLossMax

Derived from requirements:

OSS-REQ-0111: Science Image Archiving Reliability

4.1.5 Archive Processing Provenance

ID: DMS-REQ-0386 (Priority: 1b)

Specification: The Data Management System shall archive all processing provenance associated with archived data products, including relevant data from other subsystems.

Derived from requirements:

OSS-REQ-0172: Provenance Archiving

4.1.6 Image Archive

ID: DMS-REQ-0066 (Priority: 1a)

Specification: All image Data Products produced by the DMS (Processed Science Exposures, Calibration Exposures, Coadded Exposures) shall either be archived, or be capable of being recreated on-demand from inputs and processing provenance. All image Data Products produced by the DMS will record sufficient provenance information to enable recreation of the data products.

Derived from requirements:

OSS-REQ-0409: Data Product Recreation

DMS-REQ-0003: Science Data Archive

Impacted by LCR(s):

Added per LCR-2543

Updated per LCR-3643

4.1.7 Persisting Data Products

ID: DMS-REQ-0334 (Priority: 1b)

Specification: All per-band deep coadds shall be kept indefinitely and made available to users.

Discussion: This requirement is intended to list all the derived image data products that must be archived and available for download rather than regenerated on demand. For example, in the latter category, DMS-REQ-0069 indicates in the Discussion that Processed Visit Images are not archived, and DMS-REQ-0010 indicates in the Discussion that Difference Exposures are not archived. Several categories of coadds are also not expected to be archived. NB: DMS-REQ-0346 states that the raw data shall be preserved and made available for access.

Derived from requirements:

OSS-REQ-0136: Co-added Exposures

Impacted by LCR(s):

Updated per LCR-2543

4.1.8 Un-Archived Data Product Cache

ID: DMS-REQ-0310 (Priority: 1b)

Specification: The DMS shall provide low-latency storage for un-archived data products of at least **11CacheLifetime** to enable efficient precovery and other Level-1 production measurements.

Description	Value	Unit	Name
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Lifetime in the cache of un-archived Level-1 data products.	30	day	l1CacheLifetime
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Derived from requirements:

OSS-REQ-0130: Catalogs (Level 1)

DMS-REQ-0287: DIASource Precovery

Impacted by LCR(s):

Updated per LCR-2543

4.1.9 Regenerate Un-archived Data Products (Software)

ID: DMS-REQ-0311 (Priority: 1b)

Specification: The DMS shall provide software to regenerate un-archived data products, based on archived inputs and provenance data, to within scientifically reasonable tolerances, and package it for convenient execution by users.

Discussion: Unarchived data products currently include Processed Visit Images for single visits, some Coadds, and Difference Images. Scientifically reasonable tolerances means well within the formal uncertainties of the data product, given the same production software, calibrations, and compute platform, all of which are expected to change (and improve) during the course of the survey.

Derived from requirements:

OSS-REQ-0129: Exposures (Level 1)

DMS-REQ-0066: Image Archive

OSS-REQ-0409: Data Product Recreation

Impacted by LCR(s):

Updated per LCR-2543

4.1.10 Regenerate Un-archived Data Products (Services)

ID: DMS-REQ-0399 (Priority: 1b)

Specification: The DMS shall provide IVOA standards based services for the on-demand recreation of unarchived Level 1 and Level 2 Data Products based on archived inputs and provenance data.

Discussion: This requirement is intended to mandate the use of relevant IVOA standards as of the date of its adoption, i.e., the end of 2020. As there is no specific high-level standard for the creation of on-demand data products of this nature, what is envisioned is the use of lower-level standards relevant across all such services, including the use of the UWS standard for the design of asynchronous services for long-running requests, and of the DALI and VOSI standards for service endpoints. This requirement is anticipated to be satisfied by building services around the software required by DMS-REQ-0311. The capacity of the services will be determined in the operations era based on the final decisions on which data products will be unarchived, and on user demand compared to other services.

Derived from requirements:

DMS-REQ-0066: Image Archive

OSS-REQ-0409: Data Product Recreation

Impacted by LCR(s):

Added per LCR-2543

4.1.11 Regenerate Data Products from Previous Data Releases

ID: DMS-REQ-0336 (Priority: 1b)

Specification: The DMS shall be able to regenerate data products from previous data releases to within scientifically reasonable tolerances.

Discussion: This is similar to DMS-REQ-0311, but covering prior data releases. The intent is for the software to be runnable in the same environment as was used for the original data release without the software having to be ported to a modern operating system.

Derived from requirements:

LSR-REQ-0049: Data Product Archiving

Impacted by LCR(s):

Updated per LCR-2543

4.1.12 Serve Archived Provenance

ID: DMS-REQ-0387 (Priority: 1b)

Specification: The Data Management System shall make the archived provenance data available to science users together with the associated science data products.

Derived from requirements:

OSS-REQ-0172: Provenance Archiving

4.1.13 Level 1 Data Product Access

ID: DMS-REQ-0312 (Priority: 1b)

Specification: The DMS shall maintain a "live" Level 1 Database for query by science users, updated as a result of Alert Production processing.

Derived from requirements:

OSS-REQ-0127: Level 1 Data Product Availability

OSS-REQ-0185: Transient Alert Query

4.1.14 Keep Historical Alert Archive

ID: DMS-REQ-0094 (Priority: 1b)

Specification: The DMS shall preserve and keep in an accessible state an alert archive with all issued alerts for a historical record and for false alert analysis.

Derived from requirements:

DMS-REQ-0092: Alert Attributes

OSS-REQ-0128: Alerts

4.1.15 Provide a Precovery Service

ID: DMS-REQ-0341 (Priority: 1b)

Specification: A "precovery service" shall be available to end-users to request precovery for a provided sky location across all previous visits, making the results available within **precoveryServiceElapsed** hours of the request and supporting at least **precoveryServicePeakUsers** submissions per hour.

Discussion: This is forced photometry on difference images from each visit. This will include a web interface and scriptable APIs.

Description	Value	Unit	Name
Maximum time between submitting a request and receiving the results.	24	hour	precoveryServiceElapsed
Minimum number of precovery service connections to be supported per hour.	10	integer	precoveryServicePeakUsers

Derived from requirements:

OSS-REQ-0126: Level 1 Data Products

Impacted by LCR(s):

Updated per LCR-2543

4.1.16 Level 2 and Reprocessed Level 1 Catalog Access

ID: DMS-REQ-0313 (Priority: 1b)

Specification: The DMS shall maintain both the Level-2 catalog and the reprocessed Level-1 catalog from the most recent two Data Releases for query by science users, as well as versions of the most recent catalogs generated from Special Programs data.

Discussion: There is no requirement for older data releases to be queryable.

Derived from requirements:

OSS-REQ-0186: Access to Previous Data Releases

Impacted by LCR(s):

Updated per LCR-2543

4.1.17 Catalog Queries

ID: DMS-REQ-0075 (Priority: 1a)

Specification: The catalogs shall be queryable with a structured language, such as SQL.

Discussion: Queries are expected to be generated via Science User Interfaces, and software within and external to DMS, including VO clients. The queries may be translated to (and optimized for) the native query language of the DMS database server.

Derived from requirements:

DMS-REQ-0076: Keep Science Data Archive

OSS-REQ-0176: Data Access

4.1.18 Logging of catalog queries

ID: DMS-REQ-0345 (Priority: 2)

Specification: Every query of LSST databases shall be logged. The logging shall contain at least the query itself, the user who submitted the query, the date and time the query was submitted, the execution time of the query, and the number of rows returned. The query history shall be available to the user that made the query but shall otherwise be private and only accessible by administrators.

Discussion: The logs can be used for auditing in case of a dispute regarding data release timing. They can also be used by the data access team to learn the usage patterns of the system (such as the times of day/month with high load, or the most popular queries) and provide statistics for focusing on future developments and improvements of LSST. Whilst queries are private by default, in conjunction with DMS-REQ-0291, it would be desirable for a query to be published and associated with a DOI.

Derived from requirements:

OSS-REQ-0134: Level 2 Data Product Availability

4.1.19 Catalog Export Formats

ID: DMS-REQ-0078 (Priority: 1a)

Specification: The DMS catalog archive shall provide catalog data and associated metadata on request in community standard formats:

- Comma-separated ASCII text
- IVOA VOTable format, version 1.4 or later, supporting at least the XML-based TABLEDATA payload format
- FITS tables.

Discussion: The VOTable 1.4 standard is available at <http://www.ivoa.net/Documents/VOTable/20191021>. It is likely that additional VOTable payload formats will be supported, including BINARY2. "Associated metadata" for catalogs should include catalog schema and temporal and spatial coordinate-system definitions. Full metadata will likely only be available in the VOTable format.

Derived from requirements:

DMS-REQ-0076: Keep Science Data Archive

OSS-REQ-0176: Data Access

Impacted by LCR(s):

Updated per LCR-2415

4.1.20 Maintain Archive Publicly Accessible

ID: DMS-REQ-0077 (Priority: 1b)

Specification: All releases of the DMS catalog archive shall be maintained and preserved in a publicly accessible state for the entire operational life of the LSST observatory.

Discussion: The scientific intent is satisfied by keeping data products from the current DRP release and the one prior available with low-latency, in a form readily queryable by the public. Earlier releases may be available from deep-store with potentially high latency, for bulk download by users.

Derived from requirements:

DMS-REQ-0076: Keep Science Data Archive

OSS-REQ-0186: Access to Previous Data Releases

4.1.21 Access to Previous Data Releases

ID: DMS-REQ-0363 (Priority: 3)

Specification: The LSST Project shall provide data access services for the current Level 1

data, the most recent **nDRMin** Data Releases, and multiple older Data Releases.

Description	Value	Unit	Name
Minimum number of recent data releases	2	integer	nDRMin

Derived from requirements:

OSS-REQ-0186: Access to Previous Data Releases

4.1.22 Data Access Services

ID: DMS-REQ-0364 (Priority: 3)

Specification: The data access services shall be designed to permit, and their software implementation shall support, the service of at least **nDRTot** Data Releases accumulated over the (find the actual survey-length parameter) **surveyYears**-year planned survey.

Discussion: It is an operations-era decision to choose the actual number of releases to be served, and to allocate hardware resources accordingly. The requirement is that the system delivered at the close of the MREFC construction period be capable of handling ten years of releases if the operations project chooses to allocate adequate hardware resources.

Description	Value	Unit	Name
Total number of data releases over the survey.	11	integer	nDRTot
Length of the survey in years	10	integer	surveyYears

Derived from requirements:

OSS-REQ-0396: Data Access Services

4.1.23 Operations Subsets

ID: DMS-REQ-0365 (Priority: 2)

Specification: The data access services shall be designed to permit the service of operations-designated subsets of the full content of the “older Data Releases” referred to in DMS-REQ-0363.

Discussion: This requirement, and the following one, are intended to give the operations project flexibility in, for example, serving only catalogs, and not images, from older releases.

Derived from requirements:

OSS-REQ-0398: Operations Subsets

4.1.24 Subsets Support

ID: DMS-REQ-0366 (Priority: 2)

Specification: The data access services shall be designed to support the service of operations-designated subsets of the content of the “older Data Releases” referred to in requirement DMS-REQ-0363 from high-latency media.

Discussion: This means that the “toolkit” of data access services should include elements that, for instance, allow users to understand that certain queries (e.g., for data on tape) may take much longer than for current data releases, and to monitor the status of such queries.

Derived from requirements:

OSS-REQ-0400: Subsets Support

4.1.25 Access Services Performance

ID: DMS-REQ-0367 (Priority: 2)

Specification: The data access services for the most recent **nDRMin** Data Releases shall meet the performance requirements set forth in OSS-REQ-0180 and OSS-REQ-0181.

Description	Value	Unit	Name
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Minimum number of recent data releases	2	integer	nDRMin
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Derived from requirements:

OSS-REQ-0394: Access Services Performance

4.1.26 Implementation Provisions

ID: DMS-REQ-0368 (Priority: 3)

Specification: Nothing in the design and software implementation of the data access services shall prevent the performance requirements set forth in OSS-REQ-0180 and OSS-REQ-0181 from being met for the “older Data Releases” referred to in DMS-REQ-0363, subject to the provision of sufficient computing and storage resources in the operations era.

Discussion: It is left to the operations project to set standards for the performance on older releases, but they should not be limited by design choices made in the construction era. That is, the system must be scalable to handle full-performance service of all Data Releases, should the operations project so choose. This situation does not arise until, at the release of Data Release (**nDRMin**+1), the operations project must decide on the level of service to be provided for Data Release 1.

This requirement may be verified by analysis, e.g., by expert review of the design of the data access services, as it is recognized that it may be very difficult to perform live performance measurements relevant to the scalability of the data access services across a decade.

While the system is required to be scalable to full performance, it is likely that, for the optimal allocation of limited operations-era resources, performance parameters such as the number of concurrently running queries or image requests may be reduced for products from older data releases.

Description	Value	Unit	Name
Minimum number of recent data releases	2	integer	nDRMin

Derived from requirements:

OSS-REQ-0399: Implementation Provisions

4.1.27 Evolution

ID: DMS-REQ-0369 (Priority: 1b)

Specification: The data access services shall be designed to accommodate evolution of the LSST data model from Data Release to Data Release.

Derived from requirements:

OSS-REQ-0395: Evolution

4.1.28 Older Release Behavior

ID: DMS-REQ-0370 (Priority: 3)

Specification: Apart from the flexibility provided by requirements DMS-REQ-0365, DMS-REQ-0366, DMS-REQ-0368, and DMS-REQ-0369, the qualitative behavior of the data access services on the “older Data Releases” defined in DMS-REQ-0363 shall match that for the most recent **nDRMin** Data Releases.

Discussion: Essentially, the data access services should present the same APIs and user interfaces for all Data Releases except where a difference is required by a change in the data model or, e.g., by changes in UI that may be required to provide an acceptable interface for high-latency data service.

Description	Value	Unit	Name
Minimum number of recent data releases	2	integer	nDRMin

Derived from requirements:

OSS-REQ-0397: Older Release Behavior

4.1.29 Query Availability

ID: DMS-REQ-0371 (Priority: 3)

(Goal) A query (e.g., in ADQL) written against a particular Data Release SHOULD continue to be executable against the original Data Release for as long as it is available in the system, with few, if any, modifications.

Discussion: This is not a full “shall” requirement because there may be constraints imposed by, e.g., the evolution of security models, that do not permit all existing services to be retained unchanged indefinitely. The construction project should attempt to design interfaces that are resilient to reasonably anticipatable changes, and the operations project should attempt to preserve backwards compatibility where feasible.

Note that, in comparison, it clearly cannot be guaranteed that queries developed for earlier Data Releases will be usable unchanged against newer Data Releases (see also requirement OSS-REQ-0395). Users must anticipate that the evolution of the LSST pipelines will lead to changes in the Data Release schemas, though the Project will endeavor to avoid unnecessary changes.

Derived from requirements:

OSS-REQ-0401: Query Availability

4.1.30 Secure Data Storage

ID: DMS-REQ-0400 (Priority: 1b)

Specification: The DMS shall store image data in encrypted storage under secure conditions with limited access to authorized staff during the period of **L1EmbargoTmin**.

Description	Value	Unit	Name
Time images and other products (except alerts) will be embargoed before release to the consortium (or the public)	80	hour	L1EmbargoTmin

Derived from requirements:

OSS-REQ-0108: Cyber Security Agency Requirements

Impacted by LCR(s):

Added per LCR-3543

4.2 Computational Infrastructure

4.2.1 Data Management Unscheduled Downtime

ID: DMS-REQ-0318 (Priority: 1b)

Specification: The Data Management subsystem shall be designed to facilitate unplanned repair activities expected not to exceed **DMDowntime** days per year.

Discussion: This requirement does not apply to DM's alert publication and other data processing and user-interaction functionality, but only to failures in DM that directly prevent the collection of survey data. The reference case would be a failure of communication or archiving that lasted longer than the capacity of the Summit buffer -- i.e., an 11-day outage would exceed the nominal buffer capacity by one day and therefore use up the proposed allocation.

This requirement does not invoke the need to verify by reliability analysis. Verification is by analysis that identifies likely hardware failures and identifies mitigations to minimize downtime caused by those failures.

Description	Value	Unit	Name
Unplanned downtime per year.	1	day	DMDowntime

Derived from requirements:

OSS-REQ-0373: Unscheduled Downtime Subsystem Allocations

4.2.2 Optimization of Cost, Reliability and Availability in Order

ID: DMS-REQ-0161 (Priority: 1b)

Specification: Within a fixed cost envelope for the Data Management subsystem, the

allocation of processing and storage facilities will optimize reliability over availability to end users.

4.2.3 Compute Platform Heterogeneity

ID: DMS-REQ-0314 (Priority: 1b)

Specification: At any given LSST computational facility the DMS shall be capable of operations on a heterogeneous cluster of machines. The hardware, operating system, and other machine parameters shall be limited to a project-approved set.

Discussion: The necessity of replacing hardware throughout the course of the survey essentially guarantees heterogeneity within a cluster.

Derived from requirements:

OSS-REQ-0177: Data Access Environment

OSS-REQ-0124: Software Development Standards

4.2.4 Pipeline Throughput

ID: DMS-REQ-0162 (Priority: 1b)

Specification: The infrastructure will be sized such that the net throughput of the data processing pipelines will permit a complete processing of a night's observing data prior to the start of the next observing night, assuming no system outages.

Derived from requirements:

OSS-REQ-0127: Level 1 Data Product Availability

OSS-REQ-0020: Usable Observing Time

4.2.5 Pipeline Availability

ID: DMS-REQ-0008 (Priority: 1b)

Specification: Except in cases of major disaster, the DMS shall have no unscheduled outages of the DMS pipelines extending over a period greater than **productionMaxDowntime**. A major disaster is defined as a natural disaster or act of war (e.g. flood, fire, hostile acts) that compromises or threatens to compromise the health and integrity of the DMS physical facility, computing equipment, or operational personnel.

Discussion: This applies to active productions only. It is allowed for the Alert Production to be down for longer periods during observatory scheduled maintenance, and for the Data Release Production to be down during development and validation periods between productions.

Description	Value	Unit	Name
Maximum allowable outage of active DM production.	24	hour	productionMax Downtime

4.2.6 Re-processing Capacity

ID: DMS-REQ-0163 (Priority: 1b)

Specification: The DMS shall provide Processing, Storage, and Network resources capable of executing the DMS Data Release Production over all pre-existing survey data in a time no greater than **drProcessingPeriod**, without impacting observatory operations.

Description	Value	Unit	Name
Duration of the Data Release Production, including quality validation.	1	year	drProcessingPeriod

Derived from requirements:

OSS-REQ-0134: Level 2 Data Product Availability

4.2.7 Temporary Storage for Communications Links

ID: DMS-REQ-0164 (Priority: 1b)

Specification: The infrastructure will provide for temporary storage for a minimum of **tempStorageRelMTTR** of the mean time to repair of any communications network link at or before the source end of that link.

Description	Value	Unit	Name
Temporary storage required relative to network Mean Time to Repair.	200	percent	tempStorageRel MTTR

Derived from requirements:

DMS-REQ-0162: Pipeline Throughput

4.2.8 Infrastructure Sizing for "catching up"

ID: DMS-REQ-0165 (Priority: 1b)

Specification: The infrastructure will be sized such that after outages, "catch up" processing of the temporarily stored raw image data may occur at the rate of one night's observing data processed per day, without interrupting the current day's observatory operations.

Derived from requirements:

DMS-REQ-0162: Pipeline Throughput

OSS-REQ-0050: Summit Power Grid Loss

OSS-REQ-0051: Summit-Base Connectivity Loss

OSS-REQ-0052: Summit Data Buffer

4.2.9 Incorporate Fault-Tolerance

ID: DMS-REQ-0166 (Priority: 1b)

Specification: The infrastructure will incorporate as fault-tolerance features to prevent loss of data in the event of hardware or software failure.

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

4.2.10 Incorporate Autonomics

ID: DMS-REQ-0167 (Priority: 2)

Specification: The infrastructure will incorporate sufficient capability for self-diagnostics and recovery to provide for continuation of processing in the event of partial hardware or software failures.

Discussion: It is understood that the system performance may degrade with increasing numbers of failures.

Derived from requirements:

DMS-REQ-0166: Incorporate Fault-Tolerance

4.3 Summit Facility

4.3.1 Summit Facility Data Communications

ID: DMS-REQ-0168 (Priority: 1a)

Specification: The DMS shall provide data communications infrastructure to accept science data and associated metadata read-outs, and the collection of ancillary and engineering data, for transfer to the base facility.

Derived from requirements:

OSS-REQ-0002: The Summit Facility

4.3.2 Prefer Computing and Storage Down

ID: DMS-REQ-0170 (Priority: 1b)

Specification: The DMS computing and storage equipment will be preferentially located at a lower altitude Facility (Base or Archive Center) versus the Summit Facility due to lower support costs and fewer reliability issues. Therefore any processing that can be done in either location will be allocated to a lower altitude Facility.

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

4.3.3 (Descoped) ~~DMS Communication with OCS~~

ID: ~~DMS-REQ-0315 (Priority: 1a)~~

Specification: ~~The DMS at the Base Site shall contain a component to accept control commands from and communicate with the OCS.~~

Derived from requirements:

~~OSS-REQ-0003: The Base Facility~~

Impacted by LCR(s):

Descoped per LCR-3643

4.3.4 Summit to Archive Secure Data Transfer

ID: DMS-REQ-0401 (Priority: 1b)

Specification: The DMS shall implement secure data transfer between the Summit and the Archive facility using hardware based AES encryption.

Derived from requirements:

OSS-REQ-0108: Cyber Security Agency Requirements

Impacted by LCR(s):

Added per LCR-3543

4.3.5 Summit Facility Infrastructure

ID: DMS-REQ-0176 (Priority: 1a)

Specification: The Summit Facility shall provide sufficient computing, storage, and network infrastructure to support buffering and forwarding of all raw image data to the Archive

Facility and compute facilities to support Commissioning activities.

Derived from requirements:

OSS-REQ-0002: The Summit Facility

Impacted by LCR(s):

Updated per LCR-3683

4.4 Summit to Base

4.4.1 Summit to Base Network

ID: DMS-REQ-0171 (Priority: 1a)

Specification: The DMS shall provide communications infrastructure between the Summit Facility and the Base Facility sufficient to carry scientific data and associated metadata for each image in no more than time **summToBaseMaxTransferTime**.

Description	Value	Unit	Name
Maximum time interval to transfer a full Crosstalk Corrected Exposure and all related metadata from the Summit Facility to the Base facility.	2	second	summToBaseMaxTransferTime

Derived from requirements:

OSS-REQ-0003: The Base Facility

OSS-REQ-0127: Level 1 Data Product Availability

4.4.2 Summit to Base Network Availability

ID: DMS-REQ-0172 (Priority: 1b)

Specification: The Summit to Base communications shall be highly available, with Mean Time Between Failures (MTBF) > **summToBaseNetMTBF**.

Description	Value	Unit	Name
Mean time between failures, measured over a 1-yr period.	90	day	summToBaseNetMTBF

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

OSS-REQ-0373: Unscheduled Downtime Subsystem Allocations

4.4.3 Summit to Base Network Reliability

ID: DMS-REQ-0173 (Priority: 1b)

Specification: The Summit to Base communications shall be highly reliable, with Mean Time to Repair (MTTR) < **summToBaseNetMTTR**.

Description	Value	Unit	Name
Mean time to repair, measured over a 1-yr period.	24	hour	summToBaseNetMTTR

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

OSS-REQ-0373: Unscheduled Downtime Subsystem Allocations

4.4.4 Summit to Base Network Secondary Link

ID: DMS-REQ-0174 (Priority: 1b)

Specification: The Summit to Base communications shall provide at least one secondary link or transport mechanism for minimal operations support in the event of extended outage. This link may include redundant fiber optics, microwaves, or transportable media. It shall be capable of transferring one night's worth of raw data in **summToBaseNet2TransMax** or less.

Description	Value	Unit	Name
Maximum time to transfer one night of data via the network secondary link.	72	hour	summToBaseNet2TransMax

Derived from requirements:

DMS-REQ-0172: Summit to Base Network Availability

DMS-REQ-0173: Summit to Base Network Reliability

OSS-REQ-0049: Degraded Operational States

4.4.5 Summit to Base Network Operation

ID: DMS-REQ-0175 (Priority: 1b)

Specification: The Summit to Base communications link shall be operated by Rubin Observatory and/or the operations entity i.e. AURA/NOIRLab to ensure responsiveness of support.

Derived from requirements:

DMS-REQ-0173: Summit to Base Network Reliability

DMS-REQ-0172: Summit to Base Network Availability

OSS-REQ-0036: Local Autonomous Administration of System Sites

Impacted by LCR(s):

Updated per LCR-3285

4.5 Base Facility

4.5.1 (Descoped) ~~Base Facility Temporary Storage~~

ID: DMS-REQ-0177 (Priority: 1b)

Specification: The Base Facility shall provide at least a time ~~minBaseDataStorage~~ (or half of that amount, redundantly) of raw data storage in the event of Base to Archive Center network outage.

Description	Value	Unit	Name
Low-latency storage buffer capacity, expressed in units of data volume equivalent for a typical day's data collection.	14	day	minBaseDataStorage

Derived from requirements:

~~DMS-REQ-0164: Temporary Storage for Communications Links~~

~~OSS-REQ-0053: Base Archive Connectivity Loss~~

~~OSS-REQ-0054: Base Data Buffer~~

Impacted by LCR(s):

Descoped per LCR-1238

4.5.2 Base Facility Co-Location with Existing Facility

ID: DMS-REQ-0178 (Priority: 1b)

Specification: The Base Facility shall be co-located at an existing facility to leverage existing support and facility resources

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

OSS-REQ-0006: Sites

4.5.3 Commissioning Cluster

ID: DMS-REQ-0316 (Priority: 1a)

Specification: The Base Facility shall include a compute cluster to be made available to the Systems Engineering group for use in commissioning. Data Management will not administer or otherwise maintain this cluster following hardware installation. The budget for this cluster shall be at least **budgetRelAlertProd** of the budget for Alert Production hardware.

Description	Value	Unit	Name
Budget relative to the cost of the Alert Production system.	10	percent	budgetRelAlertProd

4.5.4 Base Wireless LAN (WiFi)

ID: DMS-REQ-0352 (Priority: 2)

Specification: The Base LAN shall provide **minBaseWiFi** Wireless LAN (WiFi) and Wireless Access Points in the Base Facility to support connectivity of individual user's computers to the network backbones.

Description	Value	Unit	Name
Maximum allowable outage of active DM production.	1000	megabit per second	minBaseWifi

Derived from requirements:

OSS-REQ-0003: The Base Facility

4.6 Base to Archive

4.6.1 Base to Archive Network

ID: DMS-REQ-0180 (Priority: 1b)

Specification: The DMS shall provide communications infrastructure between the Base Facility and the Archive Center sufficient to carry scientific data and associated metadata for each image in no more than time **baseToArchiveMaxTransferTime**.

Description	Value	Unit	Name
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Maximum time interval to transfer a full Crosstalk Corrected Exposure and all related metadata from the Base Facility to the Archive Center.	5	second	baseToArchiveMaxTransferTime
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Derived from requirements:

DMS-REQ-0162: Pipeline Throughput

OSS-REQ-0053: Base-Archive Connectivity Loss

OSS-REQ-0055: Base Updating from Archive

4.6.2 Base to Archive Network Availability

ID: DMS-REQ-0181 (Priority: 1b)

Specification: The Base to Archive communications shall be highly available, with MTBF > **baseToArchNetMTBF**.

Description	Value	Unit	Name
Mean time between failures, measured over a 1-yr period.	180	day	baseToArchNetMTBF

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

DMS-REQ-0162: Pipeline Throughput

OSS-REQ-0053: Base-Archive Connectivity Loss

4.6.3 Base to Archive Network Reliability

ID: DMS-REQ-0182 (Priority: 1b)

Specification: The Base to Archive communications shall be highly reliable, with MTTR < **baseToArchNetMTTR**.

Description	Value	Unit	Name
Mean time to repair, measured over a 1-yr period.	48	hour	baseToArchNet MTTR

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

OSS-REQ-0053: Base-Archive Connectivity Loss

4.6.4 Base to Archive Network Secondary Link

ID: DMS-REQ-0183 (Priority: 1b)

Specification: The Base to Archive communications shall provide a secondary link or transport mechanism (e.g. protected circuit) for operations support and "catch up" in the event of extended outage which is capable of transferring data at least the same rate as the

required minimum capacity of the primary link.

Derived from requirements:

DMS-REQ-0182: Base to Archive Network Reliability

DMS-REQ-0181: Base to Archive Network Availability

OSS-REQ-0049: Degraded Operational States

Impacted by LCR(s):

Updated per LCR-2166

4.7 Archive Center

4.7.1 Archive Center

ID: DMS-REQ-0185 (Priority: 1a)

Specification: The Archive Center shall provide computing, storage, and network infrastructure to support, simultaneously: nightly processing including image processing, detection, association, and Solar System processing, and the generation of all time-critical data products, i.e. alerts; the data release production, including Level-2 data product creation, permanent storage for all data products (with provenance).

Derived from requirements:

DMS-REQ-0163: Re-processing Capacity

OSS-REQ-0004: The Archive Facility

Impacted by LCR(s):

Updated per LCR-2376

Updated per LCR-3683

4.7.2 Archive Center Disaster Recovery

ID: DMS-REQ-0186 (Priority: 1a)

Specification: The Archive Center shall provide disaster recovery support preventing loss of LSST data in the case of infrastructure or facility-threatening events. This support shall enable recovery of all LSST archived data from backed up sources, including Data Access Centers.

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

OSS-REQ-0176: Data Access

4.7.3 Archive Center Co-Location with Existing Facility

ID: DMS-REQ-0187 (Priority: 1b)

Specification: The Archive Center shall be hosted at an existing NSF/DOE-funded supercomputing center.

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

OSS-REQ-0022: Archive Site

4.7.4 Archive Center Level-3 Products

ID: DMS-REQ-0407 (Priority: 2)

Specification: The Archive Center shall provide computing, storage, and network infrastructure to support federated Level-3 products, and serve data for replication to data centers and end user sites.

Impacted by LCR(s):

Added per LCR-3683

4.8 Archive to Data Access Center

4.8.1 Archive to Data Access Center Network

ID: DMS-REQ-0188 (Priority: 1b)

Specification: The DMS shall provide communications infrastructure between the Archive Center and Data Access Centers sufficient to carry scientific data and associated metadata in support of community and EPO access. Aggregate bandwidth for data transfers from the Archive Center to Data Centers shall be at least **archToDacBandwidth**.

Description	Value	Unit	Name
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Aggregate bandwidth capacity for data transfers between the Archive and Data Access Centers.	10000	megabit per second	archToDacBand width
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4.8.2 Archive to Data Access Center Network Availability

ID: DMS-REQ-0189 (Priority: 1b)

Specification: The Archive to Data Access Center communications shall be highly available, with MTBF > **archToDacNetMTBF**.

Description	Value	Unit	Name
Mean Time Between Failures for data service between Archive and DACs, averaged over a one-year period.	180	day	archToDacNetMTBF

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

4.8.3 Archive to Data Access Center Network Reliability

ID: DMS-REQ-0190 (Priority: 1b)

Specification: The Archive to Data Access Center communications shall be highly reliable, with MTTR < **archToDacNetMTTR**.

Description	Value	Unit	Name
Mean time to repair, measured over a 1-yr period.	48	hour	archToDacNetM TTR

Derived from requirements:

DMS-REQ-0161: Optimization of Cost, Reliability and Availability in Order

4.8.4 Archive to Data Access Center Network Secondary Link

ID: DMS-REQ-0191 (Priority: 1b)

Specification: The Archive to Data Access Center communications shall provide secondary link or transport mechanism (e.g. protected circuit) for operations support and "catch up" in the event of extended outage.

Derived from requirements:

DMS-REQ-0189: Archive to Data Access Center Network Availability

DMS-REQ-0190: Archive to Data Access Center Network Reliability

4.9 Data Access Center

4.9.1 Data Access Centers

ID: DMS-REQ-0193 (Priority: 1b)

Specification: The Data Access Centers shall provide computing, storage, and network infrastructure to support open access to LSST data products (with provenance) by end users.

Derived from requirements:

OSS-REQ-0004: The Archive Facility

4.9.2 Data Products Processing Infrastructure

ID: DMS-REQ-0396 (Priority: 2)

Specification: The Data Management System shall provide at least a fraction **userComputingFraction** of its total capability for user-dedicated processing and user-dedicated storage, including for the generation of Level 3 data products.

Discussion: This allocation does not include the resources needed to support the expected load of queries against the catalog database.

Description	Value	Unit	Name
Fraction of total computing capacity dedicated to user-defined processing	10	percent	userComputingFraction

and storage			
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Derived from requirements:

OSS-REQ-0179: Data Products Processing Infrastructure

Impacted by LCR(s):

Added per LCR-2243

4.9.3 Data Access Center Simultaneous Connections

ID: DMS-REQ-0194 (Priority: 1b)

Specification: At least **dacMinConnections** simultaneous connections shall be supported at each Data Access Center.

Description	Value	Unit	Name
Minimum simultaneous connections to end-users.	300	integer	dacMinConnections

4.9.4 Access to catalogs for external Level 3 processing

ID: DMS-REQ-0122 (Priority: 2)

Specification: The DMS shall facilitate Level 3 catalog processing that may take place at external facilities outside the DACs. This will principally be by facilitating the export of catalogs and the provision of tools for maintaining and validating exported data.

Derived from requirements:

OSS-REQ-0140: Production

OSS-REQ-0180: Data Products Query and Download Availability

4.9.5 Access to images for external Level 3 processing

ID: DMS-REQ-0126 (Priority: 2)

Specification: The DMS shall facilitate Level 3 image processing that may take place at external facilities outside the DACs. This will principally be by facilitating the export of image datasets and the provision of tools for maintaining and validating exported data.

Derived from requirements:

OSS-REQ-0140: Production

OSS-REQ-0180: Data Products Query and Download Availability

4.9.6 Access to input catalogs for DAC-based Level 3 processing

ID: DMS-REQ-0123 (Priority: 2)

Specification: The DMS shall provide access to all Level 1 and Level 2 catalog products through the LSST project's Data Access Centers, and any others that have been established

and funded, for Level 3 processing that takes place at the DACs.

Derived from requirements:

OSS-REQ-0140: Production

4.9.7 Access to input images for DAC-based Level 3 processing

ID: DMS-REQ-0127 (Priority: 2)

Specification: The DMS shall provide access to all Level 1 and Level 2 image products through the LSST project's Data Access Centers, and any others that have been established and funded, for Level 3 processing that takes place at the DACs.

Derived from requirements:

OSS-REQ-0140: Production

4.9.8 Federation with external catalogs

ID: DMS-REQ-0124 (Priority: 2)

Specification: The DMS shall provide a means for federating Level 1, 2, and 3 catalogs with externally provided catalogs, for joint analysis. The DMS shall provide specifications for how external data must be provided in order for this to be achieved. The DMS shall strive to support community standards in this regard, including, but not limited to, virtual observatory facilities that may be available during the project lifetime.

Derived from requirements:

DMS-REQ-0125: Software framework for Level 3 catalog processing

OSS-REQ-0140: Production

4.9.9 Data Access Center Geographical Distribution

ID: DMS-REQ-0196 (Priority: 1b)

Specification: The Data Access Centers will be hosted at facilities selected in at least the U.S. and the observatory host country to permit widest possible access to LSST data with the fewest possible network hops.

Derived from requirements:

DMS-REQ-0193: Data Access Centers

OSS-REQ-0021: Base Site

OSS-REQ-0022: Archive Site

4.9.10 No Limit on Data Access Centers

ID: DMS-REQ-0197 (Priority: 2)

Specification: The number of Data Access Centers shall be limited only by available internal or external funding. No architectural constraints will be placed on the DMS that prohibit the addition of Data Access Centers at any time, subject to funding.

Derived from requirements:

DMS-REQ-0193: Data Access Centers

OSS-REQ-0021: Base Site

OSS-REQ-0022: Archive Site

5 Performance Metrics

In this section we list the performance metrics for the Data Management System.

5.1 Science Metrics

5.1.1 Calculation of Photometric Performance Metrics

ID: DMS-REQ-0359 (Priority: 1a)

Specification: The DMS shall include software to enable the calculation of the photometric performance metrics defined in OSS-REQ-0387.

Discussion: The relevant metrics are listed in the table photometricPerformance below. The values in the tables are the target values for LSST but are not verified as part of this requirement.

Description	Value	Unit	Name
The RMS photometric repeatability of bright non-saturated unresolved point	7.5	millimagnitu de	PA1uzy

sources in the u , z , and y filters.			
The maximum allowable fraction of sensors with PixFrac scientifically unusable pixels.	15	percent	SensorFraction
The maximum fraction of isolated non-saturated point source measurements exceeding the outlier limit.	10	percent	PF1
Accuracy of absolute band-to-band color zero-point for colors constructed using the u-band.	10	millimagnitu de	PA5u
Repeatability outlier limit for isolated bright non-saturated point sources in the g , r , and i filters.	15	millimagnitu de	PA2gri
Accuracy of the transformation of the internal LSST photometry to a physical scale (e.g. AB magnitudes).	10	millimagnitu de	PA6
RMS width of internal photometric zero-point (precision of system uniformity across the sky) in the u-	20	millimagnitu de	PA3u

band.			
The maximum local significance integrated over the PSF of imperfect crosstalk corrections.	3	sigma	Xtalk
Repeatability outlier limit for isolated bright non-saturated point sources in the u , z , and y filters.	22.5	millimagnitu de	PA2uzy
The RMS photometric repeatability of bright non-saturated unresolved point sources in the g , r , and i filters.	5	millimagnitu de	PA1gri
Fraction of zeropoint errors that can exceed the zero point error outlier limit.	10	percent	PF2
The maximum fraction of pixels scientifically unusable per sensor out of the total allowable fraction of sensors meeting this performance.	1	percent	PixFrac
The maximum error in the precision of	1	percent	SBPrec

the sky brightness determination.			
RMS width of internal photometric zero-point (precision of system uniformity across the sky) for all bands except u-band.	10	millimagnitude	PA3
Percentage of image area that can have ghosts with surface brightness gradient amplitude of more than 1/3 of the sky noise over 1 arcsec.	1	percent	GhostAF
Accuracy of absolute band-to-band color zero-point for all colors constructed from any filter pair, excluding the u-band.	5	millimagnitude	PA5
Maximum RMS of the ratio of the error in integrated flux measurement between bright, isolated, resolved sources less than 10 arcsec in diameter and bright, isolated unresolved point sources.	2	unitless	ResSource

The zero point error outlier limit.	15	millimagnitude	PA4
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Derived from requirements:

OSS-REQ-0387: Photometric Performance

Impacted by LCR(s):

Updated per LCR-2004

5.1.2 Calculation of Astrometric Performance Metrics

ID: DMS-REQ-0360 (Priority: 1a)

Specification: The DMS shall include software to enable the calculation of the astrometric performance metrics defined in OSS-REQ-0388.

Discussion: The relevant metrics are listed in the table below. The values in the tables are the target values for LSST but are not verified as part of this requirement.

Description	Value	Unit	Name
Median relative astrometric measurement error on 20 arcminute scales.	10	milliarcsecond	AM2

The maximum fraction of relative astrometric measurements on 5 arcminute scales to exceed 5 arcminute outlier limit.	10	percent	AF1
Median relative astrometric measurement error on 5 arcminute scales shall be less than AM1 .	10	milliarcsecond	AM1
Median error in absolute position for each axis, RA and DEC, shall be less than AA1 .	50	milliarcsecond	AA1
20 arcminute outlier limit.	20	milliarcsecond	AD2
The color difference outlier limit for separations measured relative the r-band filter in any other filter.	20	milliarcsecond	AB2
5 arcminute outlier limit.	20	milliarcsecond	AD1
Median relative astrometric measurement error on 200 arcminute	15	milliarcsecond	AM3

scales.			
200 arcminute outlier limit.	30	milliarcsecond	AD3
The maximum fraction of relative astrometric measurements on 20 arcminute scales to exceed 20 arcminute outlier limit.	10	percent	AF2
Fraction of separations measured relative to the r-band that can exceed the color difference outlier limit.	10	percent	ABF1
RMS difference between separations measured in the r-band and those measured in any other filter.	10	milliarcsecond	AB1
Fraction of relative astrometric measurements on 200 arcminute scales to exceed 200 arcminute outlier limit.	10	percent	AF3

Derived from requirements:

OSS-REQ-0388: Astrometric Performance

Impacted by LCR(s):

Updated per LCR-1915

5.1.3 Calculation of Ellipticity Correlations

ID: DMS-REQ-0362 (Priority: 1b)

Specification: The DMS shall include software to enable the calculation of the ellipticity correlations metrics defined in OSS-REQ-0403, OSS-REQ-0404, and OSS-REQ-0405.

Discussion: The relevant metrics are listed in the table below. The values in the tables are the target values for LSST but are not verified as part of this requirement.

Description	Value	Unit	Name
Maximum full-survey median for residual ellipticity correlations at scales greater than or equal to 5 arcmin.	1.0e-7	unitless (angular correlation)	TE2
Maximum fraction of visit images that may exceed the TE3 or TE4 limits.	15	percent	TEF
Per-image limit on the median residual ellipticity correlations at scales greater than or equal to 5 arcmin.	2.0e-7	unitless (angular correlation)	TE4

Maximum full-survey median for residual ellipticity correlations at scales less than or equal to 1 arcmin.	2.0e-5	unitless (angular correlation)	TE1
Per-image limit on the median residual ellipticity correlations at scales less than 5 arcmin.	4.0e-5	unitless (angular correlation)	TE3

Derived from requirements:

OSS-REQ-0403: Ellipticity Correlation Function Distribution per Image

OSS-REQ-0404: Ellipticity Correlation Function Distribution for Full Survey (medians)

OSS-REQ-0405: Ellipticity Correlation Function Distribution for Full Survey (continuity)

Impacted by LCR(s):

Updated per LCR-1554

5.2 Database Performance

These requirements were originally approved in narrative text in LDM-135.

5.2.1 Result latency for high-volume full-sky queries on the Object table

ID: DMS-REQ-0357 (Priority: 1b)

Specification: High-volume queries on the Object table -- queries that involve full-sky scans -
- shall be answered in **hvObjectQueryTime**.

Description	Value	Unit	Name
Maximum time allowed for retrieving results of a high-volume query of the Object table.	1	hour	hvObjectQueryTime

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.2.2 Result latency for high-volume complex queries

ID: DMS-REQ-0354 (Priority: 1b)

Specification: Complex high-volume queries -- queries that involve full-sky spatial and temporal correlations -- shall be answered in less than **hvComplexQueryTime**.

Discussion: This can include the ForcedSource and Object_Extra tables.

Description	Value	Unit	Name
Maximum time allowed for retrieving results of a high-volume complex query.	12	hour	hvComplexQueryTime

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.2.3 Simultaneous users for high-volume queries

ID: DMS-REQ-0361 (Priority: 1b)

Specification: The system shall support **hvQueryUsers** simultaneous high-volume queries running at any given time.

Description	Value	Unit	Name
Minimum number of simultaneous users performing high volume queries.	50	integer	hvQueryUsers

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.2.4 Real time query performance

ID: DMS-REQ-0356 (Priority: 1b)

Specification: Low volume queries, queries that are spatially restricted to a circle of radius **lvSkyRadius** and return at most **lvMaxReturnedResults** of data, shall respond within

lvQueryTime under a load of **lvQueryUsers** simultaneous queries.

Discussion: We are evaluating whether the latency requirements of low-volume queries can also be met for certain categories of temporal queries or queries on indexed attributes which limit the scope of per-row operations in the query (such as non-indexed WHERE evaluations) to a comparable fraction of the total dataset. The low-volume query requirements also apply to queries selecting data by the primary key of any data product table, or by the associated Object-like primary key for the ForcedSource and DIASource tables.

Description	Value	Unit	Name
Radius to be used for a low-volume query on the sky.	60	arcsecond	lvSkyRadius
Maximum size of a results set for a query to be defined to be "low-volume".	0.5	gigabyte	lvMaxReturnedResults
Minimum number of simultaneous users performing low volume queries.	100	integer	lvQueryUsers
Maximum time allowed for retrieving results of a low-volume query.	10	second	lvQueryTime

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.2.5 Level 1 Database Query Performance

ID: DMS-REQ-0355 (Priority: 1b)

Specification: The live Prompt Products Database shall support at least **l1QueryUsers** simultaneous queries, assuming each query lasts no more than **l1QueryTime**.

Description	Value	Unit	Name
Maximum time allowed for retrieving results of a query of the Prompt Products Database.	10	second	l1QueryTime
Minimum number of simultaneous users querying the Prompt Products Database.	20	integer	l1QueryUsers

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.2.6 DM EFD Query Performance

ID: DMS-REQ-0358 (Priority: 1a)

Specification: The DM copy of the EFD shall support at least **dmEfdQueryUsers** simultaneous queries, assuming each query lasts no more than **dmEfdQueryTime**.

Description	Value	Unit	Name
Minimum number of simultaneous users querying the DM EFD.	5	integer	dmEfdQueryUsers
Maximum time allowed for retrieving results of a DM EFD query.	10	second	dmEfdQueryTime

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.3 Image Access Performance Metrics

5.3.1 Simultaneous Image Access Performance

ID: DMS-REQ-0378 (Priority: 2)

Specification: All the enclosed performance metrics shall be met simultaneously.

Discussion: While these image access requirements specify maximum timings and minimum

capacities for retrieval by a particular mechanism (VO services), it should be noted that simultaneous usage of other access mechanisms will in practice increase timings and/or reduce available capacity.

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.3.1.1 Retrieval of postage stamp light curve images

ID: DMS-REQ-0375 (Priority: 2)

Specification: Postage stamp cutouts, of size **postageStampSize** square, of all observations of a single Object shall be retrievable within **postageStampRetrievalTime**, with **postageStampRetrievalUsers** simultaneous requests of distinct Objects.

Discussion: The performance targets for this requirement assume the PVLs are available as files on a file system. For example, this could be those files present in the **l1CacheLifetime** cache.

Description	Value	Unit	Name
Maximum time allowed for retrieving a set of postage stamp images of a single Object.	10	second	postageStampRetrievalTime

Minimum square size of a postage stamp cutout from an image.	51	pixel	postageStampSize
Lifetime in the cache of un-archived Level-1 data products.	30	day	l1CacheLifetime
Minimum number of simultaneous users retrieving a set of postage stamp images.	10	integer	postageStampRetrievalUsers

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.3.1.2 Retrieval of a PVI from a single CCD

ID: DMS-REQ-0374 (Priority: 1b)

Specification: A Processed Visit Image of a single CCD shall be retrievable using the VO SIAv2 protocol within **pviRetrievalTime** with **pviRetrievalUsers** simultaneous requests for distinct single-CCD PVIs.

Discussion: The performance targets for this requirement assume the PVIs are available as files on a file system. For example, this could be those files present in the **l1CacheLifetime** cache.

Description	Value	Unit	Name
Maximum time allowed for retrieving a PVI image of a single CCD from a single visit	10	second	pviRetrievalTime
Minimum number of simultaneous users retrieving a single PVI image.	20	integer	pviRetrievalUsers
Lifetime in the cache of un-archived Level-1 data products.	30	day	l1CacheLifetime

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.3.1.3 Retrieval of focal-plane visit images

ID: DMS-REQ-0376 (Priority: 1b)

Specification: All Processed Visit Images for a single visit that are available in cache, including mask and variance planes, shall be identifiable with a single IVOA SIAv2 service query and retrievable, using the link(s) provided in the response, within **allPviRetrievalTime**. This requirement shall be met for up to **allPviRetrievalUsers** simultaneous requests for distinct focal-plane PVI sets.

Discussion: The performance targets for this requirement assume the PVI are available as files on a file system. For example, this could be those files present in the **l1CacheLifetime** cache.

Description	Value	Unit	Name
Minimum number of simultaneous users retrieving all PVI images for a visit.	10	integer	allPviRetrievalUsers
Maximum time allowed for retrieving all PVI images of a single visit.	60	second	allPviRetrievalTime
Lifetime in the cache of un-archived Level-1 data products.	30	day	l1CacheLifetime

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.3.1.4 Retrieval of a CCD-sized image from a coadd

ID: DMS-REQ-0377 (Priority: 1b)

Specification: A CCD-sized cutout of a coadd, including mask and variance planes, shall be retrievable using the IVOA SODA protocol within **ccdRetrievalTime** with **ccdRetrievalUsers** simultaneous requests for distinct areas of the sky.

Description	Value	Unit	Name
Minimum number of simultaneous users retrieving a single CCD-sized coadd cutout.	20	integer	ccdRetrievalUsers
Maximum time allowed for retrieving a CCD-sized coadd cutout.	15	second	ccdRetrievalTime

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure

5.3.1.5 Retrieval of focal-plane-sized images

ID: DMS-REQ-0373 (Priority: 2)

Specification: A 10 square degree coadd, including mask and variance planes, shall be retrievable using the IVOA SODA protocol within **fplaneRetrievalTime** with **fplaneRetrievalUsers** simultaneous requests for distinct areas of the sky.

Description	Value	Unit	Name
Number of simultaneous users retrieving a single large area coadd.	10	integer	fplaneRetrieval Users
Maximum time allowed for retrieving a focal-plane sized coadd.	60	second	fplaneRetrievalT ime

Derived from requirements:

OSS-REQ-0181: Data Products Query and Download Infrastructure