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Data Management

Distributed Database Software Test Specification

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LDM-552

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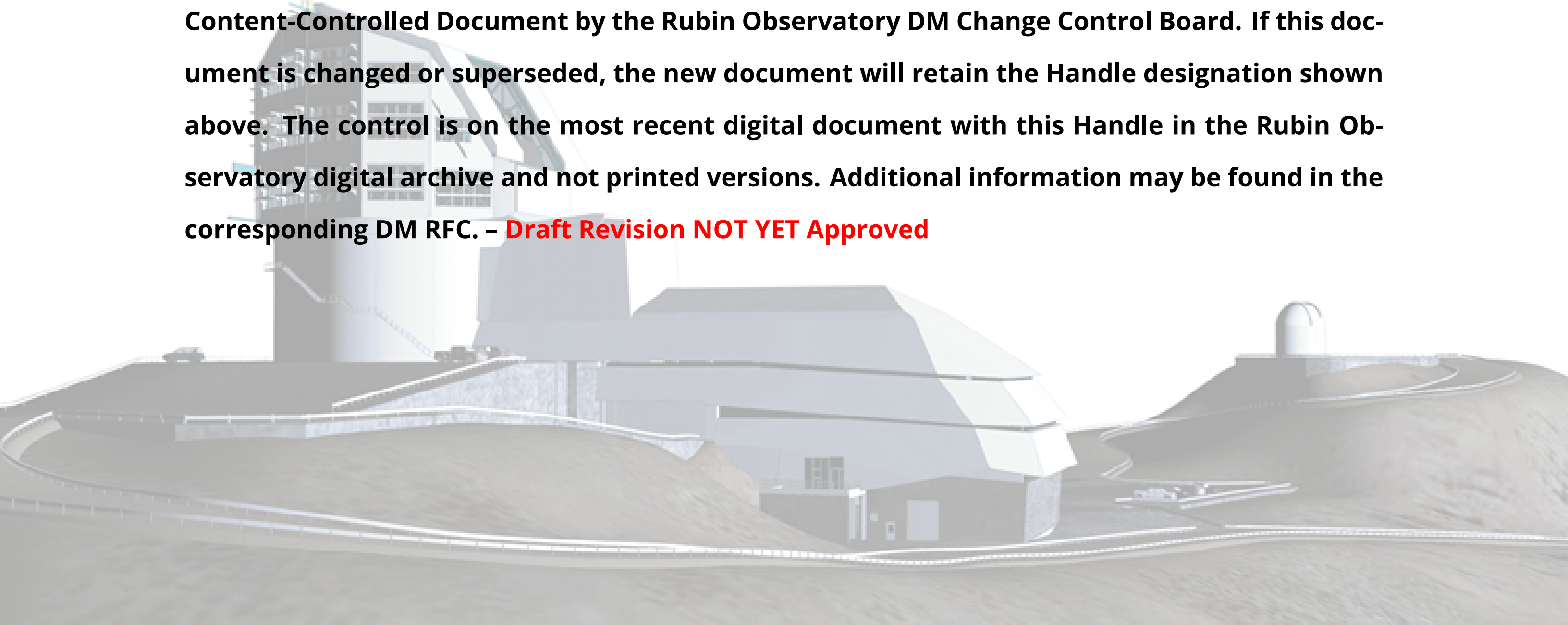

Abstract

This document describes the detailed test specification for the Distributed Database.

Change Record

Version	Date	Description	Owner name
	2017-07-02	Initial draft.	F. Mueller
1.0	2019-07-25	Document issued. Approved in RFC-612.	G. Comoretto

Document source location: `https://github.com/lsst/LDM-552`

Contents

Distributed Database Software Test Specification

1 Introduction

This document specifies the test procedure for Distributed Database. Distributed Database is a distributed shared-nothing RDBMS which will host LSST catalogs.

1.1 Objectives

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

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

1.2 Scope

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

- Parallel Distributed Database (Qserv)

1.3 Applicable Documents

LDM-135	LSST Qserv Database Design
LDM-294	LSST DM Organization & Management
LDM-502	The Measurement and Verification of DM Key Performance Metrics
LDM-503	LSST DM Test Plan
LDM-555	LSST DM Database Requirements

2 Approach

The approaches taken for the tests described here are:

- Ongoing inspection of design documents, code, and CI system logs to verify that Distributed Database design and implementation meet DM software quality standards in general, and requirements as expressed in LDM-555 in particular;
- Ongoing deployment and continuous operation of Distributed Database in a Prototype Data Access Center (PDAC) in order to assess basic reliability, fitness for purpose, and integration with adjacent subsystems;
- Annual deployment of Distributed Database to test clusters, followed by synthesis and ingestion of test datasets and scripted performance/load/stress testing. The cluster size/capabilities and the scale of the synthetic test dataset are both evolved along a path toward anticipated LSST operational scale.

2.1 Tasks and criteria

Distributed Database is a containerized, distributed, Linux application, which is deployed on machine clusters. At the scales to be tested, these clusters are comprised of one to several head (”czar”) nodes and additionally on the order of tens to hundreds of shard (”worker”) nodes, interconnected locally via a high-performance network. Head and shard nodes are provisioned each with on the order of 10s of gigabytes of RAM, and each with on the order of 10s of terabytes of locally attached storage.

Ongoing deployment, continuous operation, and integration tests are carried out on machines within the Prototype Data Access Center (PDAC), a dedicated machine cluster physically located at NCSA’s National Peta-scale Compute Facility, maintained by NCSA staff. Catalog datasets which are maintained within the PDAC Qserv instance and which are used for this testing include, simultaneously:

- An LSST stack reprocessed version of the SDSS Stripe 82 catalog (currently from Summer 2013 [Document-15097]) (~10 TB);
- IRSA AllWISE and NEOWISE catalogs (~50 TB);

- An LSST stack reprocessed version of the HSC catalog (scheduled; ~50 TB).

Tasks required for these tests include periodic update of the software deployed on the PDAC, periodic ingest of additional test datasets, and inter-operation with adjacent subsystems. Uptime is monitored cumulatively throughout these activities to gain quantitative insight into system stability and reliability.

Scaling, load, and stress testing are carried out on an additional machine cluster located CC-IN2P3 in Lyon, maintained by CC-IN2P3 staff. Scaling tests are run annually, by issuing a representative mix of concurrent queries against a synthetic catalog while monitoring average query execution times per query type. The scaling test dataset size and query concurrency level are increased each year on a glide path toward the full scale of Data Release 1.

Tasks required for these tests include generation and ingest of each successive test dataset, and execution of scripts which issue and monitor the suites of representative test queries.

2.2 Features to be tested

This version of the Distributed Database test specification addresses only basic product verification, basic reliability, and performance/scale testing – a bare minimum required to conduct ongoing development and verify that Distributed Database remains on a realistic path towards meeting its most technically challenging requirements: those related to successful operability at the scale that will be required by LSST.

2.2.1 Performances

In order to ensure that QSERV is able to meet the performance, specific test cases have been designed. These test cases will be executed each year, in order to denmonstrate that query performances are as described in the following table.

Query Class		2015	2016	2017	2018	2019	2020
Dataset size, relative to DR-1		10%	20%	30%	50%	75%	100%
LV	**# queries**	50	60	70	80	90	100
	time (sec)	10	10	10	10	10	10
FTSObj	**# queries**	3	4	8	12	16	20
	time (hours)	12	1	1	1	1	1
FTSSrc	**# queries**	1	1	2	3	4	5
	time (hours)	12	12	12	12	12	12
FTSFSrc	**# queries**		1	2	3	4	5
	time (hours)		12	12	12	12	12
joinObjSrc	**# queries**	1	2	4	6	8	10
	time (hours)	12	12	12	12	12	12
joinObjFSrc	**# queries**		1	2	3	4	5
	time (hours)		12	12	12	12	12
nearN	**# queries**		1	2	3	4	5
	time (hours)		1	1	1	1	1

2.3 Features not to be tested

Testing of the following are NOT YET COVERED in this specification:

- Fault-tolerance and disaster recovery;
- Schema evolution;
- Data ingest performance;
- Query reproducibility;
- Cross-match with external datasets.

It is anticipated that test specifications and cases for all of the above will be developed and added to future revisions of this document.

2.4 Pass/fail criteria

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

2.5 Suspension criteria and resumption requirements

Refer to individual test cases where applicable.

2.6 Naming convention

With the introduction of the Jira Test Management, the following definitions have to be considered:

LVV : Is the label for the “LSST Verification and Validation” project in Jira where all information regarding tests are managed.

LVV-XXX : Are Verification Elements, where XXX is the Verification Element identifier. Each Verification Element is derived from a requirement and has at least one Test Case associated. There can be multiple Verification Elements associated with a requirement.

LVV-TYYY : Are Test Cases. Each Test Case is associated with a Verification Element, where YYY is the Test Case identifier. There can be multiple test cases associated with a Verification Element.

3 Test Cases Summary

Test Id	Test Name
LVV-T1017	Qserv Preparation
LVV-T1085	Short Queries Functional Test
LVV-T1086	Full Table Scans Functional Test
LVV-T1087	Full Table Joins Functional Test
LVV-T1088	Concurrent Scans Scaling Test
LVV-T1089	Load Test
LVV-T1090	Heavy Load Test

4 Active Test Cases

This section documents all active test cases that have a status in the Jira/ATM system of Draft, Defined or Approved.

4.1 LVV-T1017 - Qserv Preparation

Version	Status	Priority	Verification Type	Owner
1	Approved	Normal	Test	Fritz Mueller

Open LVV-T1017 in Jira

4.1.1 Verification Elements

None.

4.1.2 Test Items

Before running any of the performance test cases, Qserv must be installed on an appropriate test cluster (e.g. the test machine cluster at CC-IN2P3). To upgrade Qserv software on the cluster in preparation for testing, follow directions at http://www.slac.stanford.edu/exp/lsst/qserv/2015_10/HOW
TO/cluster-deployment.html.

The performance tests will also require an appropriately sized test dataset to be synthesized and ingested, per the yearly dataset sizing schedule described in LDM-552, section 2.2.1. Tools for synthesis of ingest of test datasets may be found in the LSST GitHub repot at https://github.com/lsst-dm/db_tests_kpm*. Detailed use and context information for the tools is described in https://jira.lsstcorp.org/browse/DM-8405.

It has also been found that the Qserv shard servers must have engine-independent statistics loaded for the larger tables in the test dataset, and be properly configured so that the MariaDB query planner can make use of those statistics. More information on this issue is available at https://confluence.lsstcorp.org/pages/viewpage.action?pageId=58950786.

4.1.3 Predecessors

4.1.4 Environment Needs

4.1.4.1 Software

4.1.4.2 Hardware

4.1.5 Input Specification

4.1.6 Output Specification

4.1.7 Test Procedure

Step	Description, Input Data and Expected Result	
1	Description	Install/upgrade Qserv on a test cluster, following directions at http://www.slac.stanford.edu/exp/lsst/qserv/2015_10/HOW-TO/cluster-deployment.html
	Test Data	No data.
	Expected Result	Qserv installed
2	Description	Synthesize and load and appropriately sized test dataset per the yearly dataset sizing schedule described in LDM-552, section 2.2.1. Tools for synthesis of ingest of test datasets may be found in the LSST GitHub repot at https://github.com/lsstdm/db_tests_kpm*. Detailed use and context information for the tools is described in https://jira.lsstcorp.org/browse/DM-8405.
	Test Data	No data.
	Expected Result	Test dataset loaded

4.2 LVV-T1085 - Short Queries Functional Test

Version	Status	Priority	Verification Type	Owner

1	Approved	Normal	Test	Fritz Mueller

Open LVV-T1085 in Jira

4.2.1 Verification Elements

- LVV-33 - DMS-REQ-0075-V-01: Catalog Queries
- LVV-9787 - DMS-REQ-0356-V-04: Max time to retrieve low-volume query results

4.2.2 Test Items

The objective of this test is to ensure that the short queries are performing as expected and establish a timing baseline benchmark for these types of queries.

4.2.3 Predecessors

4.2.4 Environment Needs

4.2.4.1 Software

4.2.4.2 Hardware

4.2.5 Input Specification

QSERV has been set-up following procedure at LVV-T1017.

4.2.6 Output Specification

4.2.7 Test Procedure

Step	Description, Input Data and Expected Result	
1	Description	Execute single object selection: **SELECT** * **FROM** Object **WHERE** deepSourceId = 9292041530376264 and record execution time.
	Test Data	No data.
	Expected Result	Query runs in less than 10 seconds.

2	Description	Execute spatial area selection from Object:
		SELECT COUNT(*) FROM Object **WHERE**
		qserv_areaspec_box(316.582327, −6.839078, 316.653938, −6.781822)
		and record execution time.

	Test Data	No data.
	Expected Result	Query runs in less than 10 seconds.

4.3 LVV-T1086 - Full Table Scans Functional Test

Version	Status	Priority	Verification Type	Owner
1	Approved	Normal	Test	Fritz Mueller

Open LVV-T1086 in Jira

4.3.1 Verification Elements

- LVV-33 - DMS-REQ-0075-V-01: Catalog Queries
- LVV-188 - DMS-REQ-0357-V-01: Result latency for high-volume full-sky queries on the Object table
- LVV-185 - DMS-REQ-0354-V-01: Result latency for high-volume complex queries

4.3.2 Test Items

The objective of this test is to ensure that the full table scan queries are performing as expected and establish a timing baseline benchmark for these types of queries.

4.3.3 Predecessors

4.3.4 Environment Needs

4.3.4.1 Software

4.3.4.2 Hardware

4.3.5 Input Specification

QSERV has been set-up following procedure at LVV-T1017.

4.3.6 Output Specification

4.3.7 Test Procedure

Step	Description, Input Data and Expected Result	
1	Description	Execute query: **SELECT** ra , decl , u_psfFlux , g_psfFlux , r_psfFlux **FROM** Object **WHERE** y_shapeIxx **BETWEEN** 20 **AND** 20.1 and record execution time and output size.
	Test Data	No data.
	Expected Result	Query expected to run in less than 1 hour.

Step	Description, Input Data and Expected Result	
2	Description	Execute query: **SELECT** COUNT(*) **FROM** Source **WHERE** flux_sinc **BETWEEN** 1 **AND** 1.1 and record the execution time
	Test Data	No data.
	Expected Result	Query expected to run in less than 12 hours.
3	Description	Execute query: **SELECT** COUNT(*) **FROM** ForcedSource **WHERE** psfFlux **BETWEEN** 0.1 **AND** 0.2 and record the execution time
	Test Data	No data.
	Expected Result	Query expected to run in less than 12 hours.

4.4 LVV-T1087 - Full Table Joins Functional Test

Version	Status	Priority	Verification Type	Owner
1	Approved	Normal	Test	Fritz Mueller

Open LVV-T1087 in Jira

4.4.1 Verification Elements

- LVV-33 - DMS-REQ-0075-V-01: Catalog Queries
- LVV-185 - DMS-REQ-0354-V-01: Result latency for high-volume complex queries

4.4.2 Test Items

The objective of this test is to ensure that the full table join queries are performing as expected and establish a timing baseline benchmark for these types of queries.

4.4.3 Predecessors

4.4.4 Environment Needs

4.4.4.1 Software

4.4.4.2 Hardware

4.4.5 Input Specification

QSERV has been set-up following procedure at LVV-T1017.

4.4.6 Output Specification

4.4.7 Test Procedure

Step	Description, Input Data and Expected Result	
1	Description	Execute query: **SELECT** o.deepSourceId, s.objectId, s.id, o.ra, o.decl **FROM** Object o, Source s WHERE o.deepSourceId=s.objectId **AND** s . flux_sinc **BETWEEN** 0.3 **AND** 0.31 and record execution time.
	Test Data	No data.
	Expected Result	Query expected to run in less than 12 hours.

Step	Description, Input Data and Expected Result	
2	Description	Execute query: **SELECT** o.deepSourceId, f.psfFlux **FROM** Object o, ForcedSource f **WHERE** o.deepSourceId=f.deepSourceId **AND** f . psfFlux **BETWEEN** 0.13 **AND** 0.14 and record execution time.
	Test Data	No data.
	Expected Result	Query expected to run in less than 12 hours.

4.5 LVV-T1088 - Concurrent Scans Scaling Test

Version	Status	Priority	Verification Type	Owner
1	Approved	Normal	Test	Fritz Mueller

Open LVV-T1088 in Jira

4.5.1 Verification Elements

- LVV-185 - DMS-REQ-0354-V-01: Result latency for high-volume complex queries
- LVV-188 - DMS-REQ-0357-V-01: Result latency for high-volume full-sky queries on the Object table
- LVV-3403 - DMS-REQ-0361-V-01: Simultaneous users for high-volume queries

4.5.2 Test Items

This test will show that average completion-time of full-scan queries of the Object catalog table grows sub-linearly with respect to the number of simultaneously active full-scan queries, within the limits of machine resource exhaustion.

4.5.3 Predecessors

4.5.4 Environment Needs

4.5.4.1 Software

4.5.4.2 Hardware

4.5.5 Input Specification

1. A test catalog of appropriate size (see schedule detail in LDM-552, section 2.2.1), prepared and ingested into the Qserv instance under test as detailed in LVV-T1017.
2. The concurrency load execution script, runQueries.py, maintained in the LSST Qserv github repository here: https://github.com/lsst/qserv/blob/master/admin/tools/docker/deployment/in

4.5.6 Output Specification

4.5.7 Test Procedure

Step	Description, Input Data and Expected Result	
1	Description	Repeat steps 2 through 5 below, where “pool of interest” is taken first to be “FTSObj” and subsequently “FTSSrc”:
	Test Data	No data.
	Expected Result	At end of each pass, a graph indicating scan scaling rate and machine resource exhaustion cutoff.
2	Description	Inspect and modify the CONCURRENCY and TARGET_RATES dictionaries in the runQueries.py script. Set CONCURRENCY initially to 1 for the query pool of interest, and to 0 for all other query pools. Set TARGET_RATES for the query pool of interest to the yearly value per table in LDM-552, section 2.2.1.
	Test Data	No data.
	Expected Result	rueQueries.py script updated with appropriate values for test iteration
3	Description	Execute the runQueries.py script and let it run for at least one, but preferably several, query cycles.
	Test Data	No data.

Step	Description, Input Data and Expected Result	
	Expected Result	Test script executes producing log file.
4	Description	Examine log file output and compile performance statistics to obtain a growth curve point for the pool of interest for the test report.
	Test Data	No data.
	Expected Result	Logs indicate either successful test run, providing another growth point for curve, or errors indicating machine resource exhaustion cutoff has been reached.
5	Description	Adjust the CONCURRENCY value for the pool of interest and repeat from step 3 to establish the growth trend and machine resource exhaustion cutoff for the query pool of interest to an acceptable degree of accuracy.
	Test Data	No data.
	Expected Result	Average query execution time for full scan queries of each class should be demonstrated to grow sub-linearly in the number of concurrent queries to the limits of machine resource exhaustion.

4.6 LVV-T1089 - Load Test

Version	Status	Priority	Verification Type	Owner
1	Approved	Normal	Test	Fritz Mueller

Open LVV-T1089 in Jira

4.6.1 Verification Elements

- LVV-9786 - DMS-REQ-0356-V-03: Min number of simultaneous low-volume query users
- LVV-9787 - DMS-REQ-0356-V-04: Max time to retrieve low-volume query results
- LVV-188 - DMS-REQ-0357-V-01: Result latency for high-volume full-sky queries on the Object table
- LVV-185 - DMS-REQ-0354-V-01: Result latency for high-volume complex queries
- LVV-3403 - DMS-REQ-0361-V-01: Simultaneous users for high-volume queries

4.6.2 Test Items

This test will check that Qserv is able to meet average query completion time targets per query class under a representative load of simultaneous high and low volume queries while running against an appropriately scaled test catalog.

4.6.3 Predecessors

4.6.4 Environment Needs

4.6.4.1 Software

4.6.4.2 Hardware

4.6.5 Input Specification

QSERV has been set-up following procedure at LVV-T1017

4.6.6 Output Specification

4.6.7 Test Procedure

Step	Description, Input Data and Expected Result	
1	Description	Inspect and modify the CONCURRENCY and TARGET_RATES dictionaries in the runQueries.py script. Set CONCURRENCY and TARGET_RATES for all pools to the yearly value per table in LDM-552, section 2.2.1.
	Test Data	No data.
	Expected Result	Script updated with appropriate values.
2	Description	Execute the runQueries.py script and let it run for 24 hours.
	Test Data	No data.
	Expected Result	Script runs without error and produces output log.

Step	Description, Input Data and Expected Result	
3	Description	Examine log file output and compile average query execution times per query type; and compare to yearly target values per table in LDM-552, section 2.2.1.
	Test Data	No data.
	Expected Result	Average query times per query type equal or less than corresponding yearly target values in LDM-552, section 2.2.1.

4.7 LVV-T1090 - Heavy Load Test

Version	Status	Priority	Verification Type	Owner
1	Approved	Normal	Test	Fritz Mueller

Open LVV-T1090 in Jira

4.7.1 Verification Elements

- LVV-9786 - DMS-REQ-0356-V-03: Min number of simultaneous low-volume query users
- LVV-9787 - DMS-REQ-0356-V-04: Max time to retrieve low-volume query results
- LVV-188 - DMS-REQ-0357-V-01: Result latency for high-volume full-sky queries on the Object table
- LVV-185 - DMS-REQ-0354-V-01: Result latency for high-volume complex queries
- LVV-3403 - DMS-REQ-0361-V-01: Simultaneous users for high-volume queries

4.7.2 Test Items

This test will check that Qserv is able to meet average query completion time targets per query class under a higher than average load of simultaneous high and low volume queries while running against an appropriately scaled test catalog.

4.7.3 Predecessors

4.7.4 Environment Needs

4.7.4.1 Software

4.7.4.2 Hardware

4.7.5 Input Specification

QSERV has been set-up following procedure at LVV-T1017

4.7.6 Output Specification

4.7.7 Test Procedure

Step	Description, Input Data and Expected Result	
1	Description	Inspect and modify the CONCURRENCY and TARGET_RATES dictionaries in the runQueries.py script. Set CONCURRENCY and TARGET_RATES for LV query pool to 2020 value per table in LDM-552, section 2.2.1. Set CONCURRENCY and TARGET_RATES for all other query pools to values in next column over from current year column (or to 2020 values +10% if year is 2020) per table in LDM-552, section 2.2.1.
	Test Data	No data.
	Expected Result	Script updated with appropriate values.
2	Description	Execute the runQueries.py script and let it run for 24 hrs.
	Test Data	No data.
	Expected Result	Script runs without error and produces output log.
3	Description	Examine log file output and compile average query execution times per query type.
	Test Data	No data.
	Expected Result	Average query times per query type equal or less than corresponding yearly target values in LDM-552, section 2.2.1.

5 Reusable Test Cases

Test cases in this section are made up of commonly encountered steps that have been factored out into modular, reusable scripts. These test cases are meant solely for the building of actual tests used for verification, to be inserted in test scripts via the "Call to Test" functionality in Jira/ATM. They streamline the process of writing test scripts by providing pre-designed steps, while also ensuring homogeneity throughout the test suite. These reusable modules are not themselves verifying requirements. Also, these test cases shall not call other reusable test cases in their script.

No reusable test cases found.

6 Deprecated Test Cases

This section includes all test cases that have been marked as deprecated. These test cases will never be executed again, but have been in the past. For this reason it is important to keep them in the baseline as a reference.

No deprecated test cases found.

A Traceability

Verification Elements	High Level Requirements	Test Cases
LVV-33 - DMS-REQ-0075-V-01: Catalog Queries	DMS-REQ-0076 OSS-REQ-0176	LVV-T1085 LVV-T1086 LVV-T1087
LVV-9787 - DMS-REQ-0356-V-04: Max time to retrieve low-volume query results	OSS-REQ-0181	LVV-T1085 LVV-T1089 LVV-T1090
LVV-188 - DMS-REQ-0357-V-01: Result latency for high-volume full-sky queries on the Object table	OSS-REQ-0181	LVV-T1086 LVV-T1088 LVV-T1089 LVV-T1090
LVV-185 - DMS-REQ-0354-V-01: Result latency for high-volume complex queries	OSS-REQ-0181	LVV-T1086 LVV-T1087 LVV-T1088 LVV-T1089 LVV-T1090
LVV-3403 - DMS-REQ-0361-V-01: Simultaneous users for high-volume queries	OSS-REQ-0181	LVV-T1088 LVV-T1089 LVV-T1090
LVV-9786 - DMS-REQ-0356-V-03: Min number of simultaneous low-volume query users	OSS-REQ-0181	LVV-T1089 LVV-T1090

B References

[1] **[LDM-555]**, Becla, J., 2017, *Data Management Database Requirements*, LDM-555, URL `https://ls.st/LDM-555`

[2] **[LDM-135]**, Becla, J., Wang, D., Monkewitz, S., et al., 2017, *Data Management Database Design*, LDM-135, URL `https://ls.st/LDM-135`

[3] **[Document-15097]**, Lim, K.T., 2013, *LSST Data Challenge Report: Summer 2013*, Document-15097, URL `https://ls.st/Document-15097`

[4] **[LDM-148]**, Lim, K.T., Bosch, J., Dubois-Felsmann, G., et al., 2018, *Data Management System Design*, LDM-148, URL `https://ls.st/LDM-148`

[5] **[LDM-552]**, Mueller, F., 2017, *Qserv Software Test Specification*, LDM-552, URL `https://ls.st/LDM-552`

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

[7] **[LDM-294]**, O'Mullane, W., Swinbank, J., Jurić, M., DMLT, 2018, *Data Management Organization and Management*, LDM-294, URL `https://ls.st/LDM-294`

[8] **[LDM-503]**, O'Mullane, W., Swinbank, J., Jurić, M., Economou, F., 2018, *Data Management Test Plan*, LDM-503, URL `https://ls.st/LDM-503`

C Acronyms

Acronym	Description
ATM	Adaptavist Test Management
AURA	Association of Universities for Research in Astronomy
CC	Change Control
CC-IN2P3	Centre de Calcul de l'IN2P3
CI	Continuous Integration
DAC	Data Access Center
DM	Data Management
DMS	Data Management Subsystem
DMS-REQ	Data Management System Requirements prefix
DR	Data Release
DRP	Data Release Production
EPO	Education and Public Outreach
FITS	Flexible Image Transport System
HSC	Hyper Suprime-Cam
IN2P3	Institut National de Physique Nucléaire et de Physique des Particules
IRSA	Infrared Science Archive
LDM	LSST Data Management (Document Handle)
LSST	Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope)
NCSA	National Center for Supercomputing Applications
NSF	National Science Foundation
OSS	Observatory System Specifications; LSE-30
PDAC	Prototype Data Access Center
QA	Quality Assurance
RAM	Random Access Memory
RDBMS	Relational Database Management System
RFC	Request For Comment
SDSS	Sloan Digital Sky Survey
TB	TeraByte
US	United States