LARGE SYNOPTIC SURVEY TELESCOPE

## Large Synoptic Survey Telescope (LSST)
## Data Management

# Vera C. Rubin Network Verification Document

**Jeff Kantor**

**LDM-732**

**Latest Revision: 2020-01-30**

## Abstract

The Vera C Rubin Observatory Network Verification Document (VNVD) and associated JIRA V&V Project define the flow-down of specifications from higher level documents to the LSST Observatory Network (as defined in LSE-78 LSST Observatory Network), and the methods and resources that will be used to verify that the networks have met the specifications satisfactory for accepting the Summit Network into DM Subsystem Integration Test (DMSSIT) and LSST System Integration Test (SIT)

# Change Record

| Version | Date | Description | Owner name |
|---|---|---|---|
| | 2020-01-28 | First draft | J. Kantor |

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# Contents

# Vera C. Rubin Network Verification Document

## 1 Introduction

### 1.1 Scope

This plan governs only tests of the network infrastructure, not the applications and services that use the network. To be specific, this plan governs tests of the network only up to ISO OSI Layer `https://en.wikipedia.org/wiki/OSI_model`.

As such, all of the tests governed by this plan and defined in the LSST Verification and Validation JIRA Project (LVV) are defined as Lower Level (LL) in the System Engineering test hierarchy. LL corresponds to Data Management Subsystem Integration. Where appropriate, additional comments regarding Same Level (SL) which corresponds to LSST System Integration, and Higher Level (HL) which corresponds to LSST Commissioning, are called out in the Verification Elements.

Note that significant testing of the networks occurs prior to subsystem and system integration, i.e. prior to verification, as documented in document-14789 LSST LHN End-to-End Plan and associated test documentation (see Collection-3758).

Finally, note that one significant network, the Summit Network, is not a DM deliverable and as such is not contained within this plan. As Telescope and Site deliverable, the Summit Network is covered by the Telescope and Site V&V plans.

### 1.2 Specification Flow-down

#### 1.2.1 Data Management Subsystem Requirements Flow-down

The Data Management Subsystem Requirements (LSE-61, aka DMSR) drive the LSST Observatory Network Design for all segments except the Summit Network (see above). The DMSR sections that directly drive the VNVD are listed here for convenience. These DMSR sections contain traceable network requirements as documented in the LSST V&V JIRA Project (LVV) Verification Elements:

- 1.2.1 Nightly Data Accessible Within 24 hrs
- 2.6.3 Transient Alert Distribution
- 2.6.8 Solar System Objects Available within 24 hours
- 2.8.1 Timely Publication of Level 2 Data Releases
- 4.4 Summit to Base
- 4.6 Base to Archive
- 4.8 Archive to Data Access Center

### 1.2.2 Observatory System Specifications Flow-down

Note that the Observatory System Specifications (LSE-30, aka OSS) also include general requirements on security, disaster recovery, physical environment (including seismic activity), and shipping which are flowed down to the subsystems, and while they apply to all subsystems, including the networks, they will be tested and verified in the Telescope and Data Management Subsystem Integration Tests and in the LSST Commissioning Phase, as part of the LSST System Integration Test. Those requirements are excluded from this specification and the associated verification matrix, as they will be addressed in the applicable plans.

## 1.3 LSST Verification and Validation JIRA Project (LVV)

The LSST Verification and Validation JIRA Project lists the specifications within or derived from, and traceable to, the DMSR specifications, in Verification Elements that also specify the methods to be used to verify, the responsible parties, and additional notes regarding verification, per the LSE-160 LSST Verification and Validation Process. The Verification Elements then have one or more Test Cases associated with them that describe the implementation of the verification activities in terms of specific tests to be executed. Those Test Cases are then scheduled via Test Plans and Campaigns, and executed with results reported in Test Cycles/

## 1.4 Verification and Validation Schedule and Resources

The schedule and resources required for network verification are defined in the LSST Project Management Control System (PMCS). They are covered by the final integration test activities

in the WBS elements 02C.08.03 Long-Haul Networks. In each Verification Element, a cross-reference to the ID of the appropriate predecessor PMCS activities is provided in the pre-conditions field.

## 1.5 Applicable Documents

| | |
|---|---|
| LSE-61 | LSST DM Subsystem Requirements |
| LSE-78 | LSST Observatory Network Design |
| LSE-160 | Verification and Validation Process |

# 2 DM Network Verification Elements

Follows the list of verification elements defined in the context of DM subsystem, Network component.

## 2.1 [LVV-71] DMS-REQ-0168-V-01: Summit Facility Data Communications

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-71 | Gregory Dubois-Felsmann | Not Covered | 1a | LVV-T1097 |

**Verification Element Description:**
Verify that:

- Summit - Base Network has been properly implemented in Summit and Base facilities
- Summit - Base Network is properly integrated with Summit Control Network and DAQ/-Camera Data Backbone

Verify that OCS/DMCS triggers read-out from DAQ and queries EFD. verify that data from EFD and camera are accepted and transferred to the Summit DWDM. Requirement does not include data transfer to base (LVV-73) or from base to archive center (LVV-81, LVV-82, LVV-83).

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0168 | |
| Requirement Description | **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. | |
| Requirement Priority | 1a | |
| Upper Level Requirement | OSS-REQ-0002 | The Summit Facility |

### 2.1.1 [LVV-T1097] Verify Summit to Base Network Implementation

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T1097 | Jeff Kantor | Draft | 1 | false | Test |

**Objective:**
Control the AuxTel through a night of Observing, read out data and transfer data to LSST Summit DWDM. Verify that data acquired by a AuxTel DAQ can be transferred to LSST Summit

DWDM and loaded in EFD without problems.

**Precondition:**

1. Summit Control Network and Camera Data Backbone installed and operating properly.
2. Summit - Base Network installed and operating properly.
3. AuxTel hardware and control systems are functional with LATISS. AuxTel TCS, AuxTel EFD, AuxTel CCS, AuxTel DAQ are connected via LSST Control Network on Summit to LSST DWDM (with at least 2 x 10 Gbps ethernet port client cards).
4. AuxTel Archiver/forwarders installed in Summit and operating properly.

**Predecessors:**
PMCS DMTC-7400-2400 Complete
PMCS T&SC-2600-1545 Complete

**Test Personnel:**
Ron Lambert (LSST), Kian-Tat Lim (LSST), Matt Kollross (NCSA), Tony Johnson (SLAC), Gregg Thayer (SLAC)

## 2.2 [LVV-73] DMS-REQ-0171-V-01: Summit to Base Network

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-73 | Robert Gruendl | Not Covered | 1a | LVV-T1168<br>LVV-T1612 |

**Verification Element Description:**
This requirement must be tested in sequence and collect performance metrics (both DAQ and Control sides unless noted):

1. ISO OSI Layer 1 Physical (fibers with test data from OTDR, AURA does test)
2. ISO OSI Layer 2 Data Link (DWDM equipment, line cards, with test data from multi-channel/lightwave/channel analyzer, Installer does test, AURA certify)
3. ISO Layer 3 minimal (DWDM with 2 x 10 Gbps ethernet port client cards with test data from 4 windows test boxes, 2 on each side, Installer does test, AURA certify, can repeat as part of #4 with DAQ)
4. ISO Layer 3 full (22 x 10 Gbps ethernet ports on DAQ side with test data from DAQ test stand, AURA, Camera DAQ team do test). Transfer data between summit and base over uninterrupted 1 day period. Â Demonstrate transfer of data at or exceeding rates specified in LDM-142.

| Upstream Requirements | |
|---|---|
| Requirement ID | DMS-REQ-0171 |
| Requirement Description | **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**. |
| Requirement Parameters | **summToBaseMaxTransferTime = 2[second]** Maximum time interval to transfer a full Crosstalk Corrected Exposure and all related metadata from the Summit Facility to the Base facility. |
| Requirement Priority | 1a |
| Upper Level Requirement | OSS-REQ-0003 The Base Facility<br>OSS-REQ-0127 Level 1 Data Product Availability |

### 2.2.1 [LVV-T1168] Verify Summit - Base Network Integration

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T1168 | Jeff Kantor | Approved | 1 | false | Inspection |

**Objective:**
3 phases done (in collaboration with equipment/installation vendors):

1. Installation of fiber optic cables and Optical Time Domain Reflector (OTDR) fiber testing (completed 20170602 REUNA deliverable RD10)
2. Installation of AURA DWDM and Data Transfer Node (DTN) (completed 20171218 DMTR-82)
3. Installation of LSST DWDM and Bit Error Rate Tester (BERT) data (completed 20190505 collection-7743, 20191108 DAQ DWDM Connection Tests)

**Precondition:**
PMCS DMTC-7400-2330 COMPLETE
By phase:

1. Posts from Cerro Pachon to AURA Gatehouse repaired/improved. Fiber installed on posts from Cerro Pachon to AURA Gatehouse. Fiber installed from AURA Gatehouse to AURA compound in La Serena. OTDR purchased.
2. AURA DWDM installed in caseta on Cerro Pachon and in existing computer room in La Serena. DTN installed in La Serena. DTN loaded with software and test data staged.
3. Base Data Center (BDC) ready for installation of LSST DWDM. Fiber connecting existing computer room to BDC. LSST DWDM equipment installed in Summit Computer Room and BDC.

**Predecessors:**
See pre-conditions by phase above.

**Test Personnel:**
Ron Lambert (LSST), Albert Astudillo (REUNA), Mauricio Rojas (CTIO/CISS), Raylex, Coriant, Telefonica contractors

### 2.2.2 [LVV-T1612] Verify Summit - Base Network Integration (System Level)

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T1612 | Jeff Kantor | Draft | 1 | false | Inspection |

**Objective:**
Verify ISO Layer 3 full (22 x 10 Gbps ethernet ports on DAQ side with test data from DAQ test stand, AURA, Camera DAQ team do test). Transfer data between summit and base over uninterrupted 1 day period. Demonstrate transfer of data at or exceeding rates specified in LDM-142.

**Precondition:**
PMCS DMTC-7400-2400 COMPLETE
LVV-T1168 Passed
Full Camera DAQ installed on summit and loaded with data.
Archiver/forwarders installed at Base.

**Predecessors:**
See pre-conditions.

**Test Personnel:**
Ron Lambert (LSST), Greg Thayer (SLAC)

## 2.3 [LVV-74] DMS-REQ-0172-V-01: Summit to Base Network Availability

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-74 | Robert Gruendl | Not Covered | 1a | LVV-T185 |

**Verification Element Description:**
This requirement needs the network link to be active for a calculated amount of time (at least 1 week) without failure. Will require modeling as failures are rare. Monthly operating statistics will be acquired during commissioning. Demonstrate transfer of data at or exceeding rates specified in LDM-142, verify achieved average and peak throughput and latency.

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0172 | |
| Requirement Description | **Specification:** The Summit to Base communications shall be highly available, with Mean Time Between Failures (MTBF) > **summToBaseNetMTBF**. | |
| Requirement Parameters | **summToBaseNetMTBF = 90[day]** Mean time between failures, measured over a 1-yr period. | |
| Requirement Priority | 1b | |
| Upper Level Requirement | OSS-REQ-0373<br>DMS-REQ-0161 | Unscheduled Downtime Subsystem Allocations<br>Optimization of Cost, Reliability and Availability in Order |

### 2.3.1 [LVV-T185] Verify implementation of Summit to Base Network Availability

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T185 | Robert Gruendl | Draft | 1 | false | Inspection |

**Objective:**
Monitor summit to base networking for at least 1 week, model annual availability, and verify that the mean time between failures is less than summToBaseNetMTBF (90 days) over 1 year.

**Precondition:**
PMCS DMTC-7400-2400 Complete.
perSonar installed in Summit and publishing statistics to MadDash.

**Predecessors:**
See pre-conditions.

**Test Personnel:**
Ron Lambert (LSST)

## 2.4 [LVV-75] DMS-REQ-0173-V-01: Summit to Base Network Reliability

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-75 | Robert Gruendl | Not Covered | 1a | LVV-T186 |

**Verification Element Description:**
Disconnect, reconnect and recover transfer of data between summit and base. After disconnecting fiber at an intermediate location between summit and base, demonstrate reconnection and recovery to transfer of data at or exceeding rates specified in LDM-142 within MTTR specification. Â Network operator will provide MTTR data on links during commissioning and operations.

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0173 | |
| Requirement Description | **Specification:** The Summit to Base communications shall be highly reliable, with Mean Time to Repair (MTTR) < **summToBaseNetMTTR**. | |
| Requirement Parameters | **summToBaseNetMTTR = 24[hour]** Mean time to repair, measured over a 1-yr period. | |
| Requirement Priority | 1b | |
| Upper Level Requirement | OSS-REQ-0373<br>DMS-REQ-0161 | Unscheduled Downtime Subsystem Allocations<br>Optimization of Cost, Reliability and Availability in Order |

### 2.4.1 [LVV-T186] Verify implementation of Summit to Base Network Reliability

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T186 | Robert Gruendl | Draft | 1 | false | Demonstration |

**Objective:**
This approach is necessitated by not wanting to actually cut the fiber just for test purposes:

- Pick a point on the network (Time Domain graph) and simulate a fault (e.g. disconnect a cable).
- Detect there a fault.
- Diagnose that it is a break.

- Measure the cable with the OTDR to locate the distance from the end point.
- Elapse time to simulate the following:
  - Go to the most inaccessible place which would mean carrying all the tools/splicer/-generator/tent equipment some  metres.
  - Erect a tent to make the splice
  - Start the generator
  - Do a splice on some random piece of cable
  - At an end point measure the cable again to ensure it is break free.
  - Take down and reinstall an isolate pole (not in the actual fiber path)
  - Put the cable on the pole.
- Restore connection (e.g. reconnect cable)
- Measure with OTDR to ensure back to normal state.

**Precondition:**
PMCS DMTC-7400-2400 Complete

**Predecessors:**
See pre-conditions.

**Test Personnel:**
Ron Lambert (LSST), Guido Maulen (LSST)

## 2.5 [LVV-76] DMS-REQ-0174-V-01: Summit to Base Network Secondary Link

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-76 | Robert Gruendl | Not Covered | 1a | LVV-T187 |

**Verification Element Description:**
This requirement is verified by demonstrating use of a secondary transfer method (redundant fiber network, microwave link, or transportable medium) between Summit and Base capable of transferring 1 night of raw data (nCalibExpDay + nRawExpNightMax = 450 + 2800 = 3250 exposures) within summToBaseNet2TransMax (72 hours).

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0174 | |
| Requirement Description | **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. | |
| Requirement Parameters | **summToBaseNet2TransMax = 72[hour]** Maximum time to transfer one night of data via the network secondary link. | |
| Requirement Priority | 1b | |
| Upper Level Requirement | DMS-REQ-0173 | Summit to Base Network Reliability |
| | OSS-REQ-0049 | Degraded Operational States |
| | DMS-REQ-0172 | Summit to Base Network Availability |

### 2.5.1 [LVV-T187] Verify implementation of Summit to Base Network Secondary Link

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T187 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**
Transfer data between summit and base on primary equipment (LSST Summit - Base) over uninterrupted 1 day period. Simulate outage by disconnecting fiber from equipment on primary and verify that network fails over to secondary equipment. Demonstrate transfer of data at or exceeding rates specified in LDM-142 between summit and base over secondary

equipment uninterrupted 1 day period (except for <=60s to fail-over to secondary and recover to primary connection execution). Verify that link is capable of transferring 1 night of raw data (nCalibExpDay + nRawExpNightMax = 450 + 2800 = 3250 exposures) within summToBaseNet2TransMax (72 hours). Restore connection between fiber and primary equipment (i.e. reconnect primary), verify that network recovers to primary.

**Precondition:**
PMCS DMTC-7400-2400 complete.

**Predecessors:**
See pre-conditions.

**Test Personnel:**
Ron Lambert (LSST)

## 2.6 [LVV-77] DMS-REQ-0175-V-01: Summit to Base Network Ownership and Operation

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-77 | Robert Gruendl | Not Covered | 1a | LVV-T188 |

**Verification Element Description:**
This requirement is verified by inspecting construction and operations contracts and Indefeasible Rights to Use (IRUs).

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0175 | |
| Requirement Description | **Specification:** The Summit to Base communications link shall be owned and operated by LSST and/or the operations entity to ensure responsiveness of support. | |
| Requirement Priority | 1b | |
| Upper Level Requirement | DMS-REQ-0173 | Summit to Base Network Reliability |
| | OSS-REQ-0036 | Local Autonomous Administration of System Sites |
| | DMS-REQ-0172 | Summit to Base Network Availability |

### 2.6.1 [LVV-T188] Verify implementation of Summit to Base Network Ownership and Operation

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T188 | Robert Gruendl | Draft | 1 | false | Inspection |

**Objective:**
Inspect construction and operations contracts and Indefeasible Rights to Use (IRUs).

**Precondition:**

**Predecessors:**
PMCS DMTC-7400-2140, -2240, -2330 Complete

**Test Personnel:**

Jeff Kantor (LSST)

## 2.7 [LVV-81] DMS-REQ-0180-V-01: Base to Archive Network

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-81 | Robert Gruendl | Not Covered | 1a | LVV-T193 |

**Verification Element Description:**
This requirement is verified by transferring simulated or pre-cursor image data and metadata between base and archive over an uninterrupted 1 day period. Â Analyze the network performance and show that data can be transferred by DAQ within the required time.

| Upstream Requirements | |
|---|---|
| Requirement ID | DMS-REQ-0180 |
| Requirement Description | **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**. |
| Requirement Parameters | **baseToArchiveMaxTransferTime = 5[second]** Maximum time interval to transfer a full Crosstalk Corrected Exposure and all related metadata from the Base Facility to the Archive Center. |
| Requirement Priority | 1b |
| Upper Level Requirement | OSS-REQ-0053 Base-Archive Connectivity Loss<br>OSS-REQ-0055 Base Updating from Archive<br>DMS-REQ-0162 Pipeline Throughput |

### 2.7.1 [LVV-T193] Verify implementation of Base to Archive Network

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T193 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**
Transfer data between base and archive over uninterrupted 1 day period (with repeated transfers on normal observing cadence). Analyze the network and show that data acquired by a DAQ can be transferred within the required time, i.e. verify that link is capable of transferring image for prompt processing in oArchiveMaxTransferTime = 5[second]. Verify transfer of data at or exceeding rates specified in LDM-142.

**Precondition:**
Archiver/Forwarders are configured at Base, connected to REUNA DWDM, loaded with simulated or pre-cursor data.
Archiver/Forwarder receivers or other capability is on configured at LDF, connected to Base - Archive Network.

**Predecessors:**
PMCS DM-Net-5 Complete

**Test Personnel:**
Ron Lambert (LSST)

## 2.8 [LVV-82] DMS-REQ-0181-V-01: Base to Archive Network Availability

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-82 | Robert Gruendl | Not Covered | 1a | LVV-T194 |

**Verification Element Description:**
This requirement is verified by transferring data between base and archive over uninterrupted 1 week period, modeling to extrapolate to an annual failure rate, and verifying that is within the requirement.

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0181 | |
| Requirement Description | **Specification:** The Base to Archive communications shall be highly available, with MTBF > **baseToArchNetMTBF**. | |
| Requirement Parameters | **baseToArchNetMTBF = 180[day]** Mean time between failures, measured over a 1-yr period. | |
| Requirement Priority | 1b | |
| Upper Level Requirement | OSS-REQ-0053 | Base-Archive Connectivity Loss |
| | DMS-REQ-0162 | Pipeline Throughput |
| | DMS-REQ-0161 | Optimization of Cost, Reliability and Availability in Order |

### 2.8.1 [LVV-T194] Verify implementation of Base to Archive Network Availability

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T194 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**
Transfer data between base and archive over uninterrupted 1 week period. Extrapolate to a full year to estimate if expect to meet baseToArchNetMTBF = 180[day]. Note that this is for complete loss of transfer service (all paths), not a single path failure with successful fail-over. Demonstrate transfer of data at or exceeding rates specified in LDM-142, verify achieved average and peak throughput and latency.

**Precondition:**
Archiver/Forwarders are configured at Base, connected to REUNA DWDM, loaded with simu-

lated or pre-cursor data.
Archiver/Forwarder receivers or other capability is on configured at LDF, connected to Base - Archive Network.

**Predecessors:**
PMCS DMTC-7400-2130 Complete

**Test Personnel:**

## 2.9 [LVV-83] DMS-REQ-0182-V-01: Base to Archive Network Reliability

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-83 | Robert Gruendl | Not Covered | 1a | LVV-T195 |

**Verification Element Description:**
Disconnect, reconnect and recover transfer of data between summit and base, after disconnecting fiber at an intermediate location between base and archive

| Upstream Requirements | |
|---|---|
| Requirement ID | DMS-REQ-0182 |
| Requirement Description | **Specification:** The Base to Archive communications shall be highly reliable, with MTTR < **baseToArchNetMTTR**. |
| Requirement Parameters | **baseToArchNetMTTR = 48[hour]** Mean time to repair, measured over a 1-yr period. |
| Requirement Priority | 1b |
| Upper Level Requirement | OSS-REQ-0053 Base-Archive Connectivity Loss<br>DMS-REQ-0161 Optimization of Cost, Reliability and Availability in Order |

### 2.9.1 [LVV-T195] Verify implementation of Base to Archive Network Reliability

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T195 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**
Disconnect, reconnect and recover transfer of data between base and archive, after disconnecting fiber at an intermediate location between base and archive. Verify recovery can occur within baseToArchNetMTTR = 48[hour]. Demonstrate reconnection and recovery to transfer of data at or exceeding rates specified in LDM-142.

**Precondition:**
Archiver/Forwarders are configured at Base, connected to REUNA DWDM, loaded with simulated or pre-cursor data.
Archiver/Forwarder receivers or other capability is on configured at LDF, connected to Base -

Archive Network.

**Predecessors:**
PMCS DM-NET-5 Complete

**Test Personnel:**
Ron Lambert (LSST), Albert Astudillo (REUNA), Jeronimo Bezerra (FIU/AmLight), Matt Kollross (NCSA)

## 2.10 [LVV-84] DMS-REQ-0183-V-01: Base to Archive Network Secondary Link

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-84 | Robert Gruendl | Not Covered | 1a | LVV-T196 |

**Verification Element Description:**

This requirement is verified by disconnecting the primary link, failing over to the secondary link, reconnecting primary link, and failing back to primary link, while verifying data is transferred within required times.

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0183 | |
| Requirement Description | **Specification:** The Base to Archive communications shall provide secondary link or transport mechanism (e.g. protected circuit) for operations support and "catch up" in the event of extended outage. This secondary link shall be capable of "bursting" to at least twice the capacity of the primary link. | |
| Requirement Priority | 1b | |
| Upper Level Requirement | DMS-REQ-0181 | Base to Archive Network Availability |
| | DMS-REQ-0182 | Base to Archive Network Reliability |
| | OSS-REQ-0049 | Degraded Operational States |

### 2.10.1 [LVV-T196] Verify implementation of Base to Archive Network Secondary Link

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| Jira Link | Owner | Status | Version | Critical Event | Verification Type |
| LVV-T196 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**

FOR EACH SEGMENT (LS - SCL, SCL - FL, FL - CHI, CHI - CHMPGN): Transfer data between base and archive on primary links over uninterrupted 1 day period. Simulate outage by disconnecting fiber on primary and verify that network fails over to secondary links. Transfer data between base and archive over secondary equipment uninterrupted 1 day period. Restore connection on primary link verify that network recovers to primary. Transfer data between base and archive on primary links over uninterrupted 1 day period. Demonstrate transfer of data at or exceeding rates specified in LDM-142 throughout fail-over period except for <=60s fail-over fail-over to secondary and recover to primary connection execution.

**Precondition:**
Archiver/Forwarders are configured at Base, connected to REUNA DWDM, loaded with simulated or pre-cursor data.
Archiver/Forwarder receivers or other capability is on configured at LDF, connected to Base - Archive Network.

**Predecessors:**
PMCS DM-NET-5 Complete
PMCS DMTC-8000-0990 Complete
PMCS DMTC-8100-2130 Complete
PMCS DMTC-8100-2530 Complete
PMCS DMTC-8200-0600 Complete

**Test Personnel:**
Ron Lambert (LSST), Albert Astudillo (REUNA), Jeronimo Bezerra (FIU/AmLight), Matt Kollross (NCSA)

## 2.11 [LVV-88] DMS-REQ-0188-V-01: Archive to Data Access Center Network

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-88 | Robert Gruendl | Not Covered | 1a | LVV-T200 |

**Verification Element Description:**
This requirement is verified by transferring data between archive and both DACs over uninterrupted 1 day period, analyzing the network performance, and verifying that data can be transferred within the required time.

| Upstream Requirements | |
|---|---|
| Requirement ID | DMS-REQ-0188 |
| Requirement Description | **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**. |
| Requirement Parameters | **archToDacBandwidth = 10000[megabit per second]** Aggregate bandwidth capacity for data transfers between the Archive and Data Access Centers. |
| Requirement Priority | 1b |
| Upper Level Requirement | OSS-REQ-0004 The Archive Facility |

### 2.11.1 [LVV-T200] Verify implementation of Archive to Data Access Center Network

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T200 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**
Transfer data between archive and both DACs over uninterrupted 1 day period (data can be simulated, i.e. files of similar size and quantity to real data). Verify can meet archToDacBandwidth = 10000[megabit per second]. Analyze the network and show that data can be transferred within the required time. Demonstrate transfer of data at or exceeding rates specified in LDM-142.

**Precondition:**

Data is staged in LDF and data transfer capabilities to US DAC and Chilean DAC are in place.

**Predecessors:**
PMCS DMTC-8100-2550 Complete

**Test Personnel:**
Ron Lambert (LSST), Albert Astudillo (REUNA), Jeronimo Bezerra (FIU/AmLight), Matt Kollross (NCSA)

## 2.12 [LVV-89] DMS-REQ-0189-V-01: Archive to Data Access Center Network Availability

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-89 | Robert Gruendl | Not Covered | 1a | LVV-T201 |

**Verification Element Description:**
This requirement needs the network link to be active for a calculated amount of time (at least 1 week) without failure. This will require modeling as failures are rare, so an annual MTBF will be estimated from test results.

| Upstream Requirements | |
|---|---|
| Requirement ID | DMS-REQ-0189 |
| Requirement Description | **Specification:** The Archive to Data Access Center communications shall be highly available, with MTBF > **archToDacNetMTBF**. |
| Requirement Parameters | **archToDacNetMTBF = 180[day]** Mean Time Between Failures for data service between Archive and DACs, averaged over a one-year period. |
| Requirement Priority | 1b |
| Upper Level Requirement | DMS-REQ-0161 Optimization of Cost, Reliability and Availability in Order |

### 2.12.1 [LVV-T201] Verify implementation of Archive to Data Access Center Network Availability

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T201 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**
Transfer data between archive and DACs over uninterrupted 1 week period. Extrapolate to 1 year to estimate can meet archToDacNetMTBF = 180[day]. Demonstrate transfer of data at or exceeding rates specified in LDM-142, verify achieved average and peak throughput and latency.

**Precondition:**

Data is staged in LDF and data transfer capabilities to US DAC and Chilean DAC are in place.

**Predecessors:**
PMCS DMTC-8100-2550 Complete

**Test Personnel:**
Ron Lambert (LSST), Albert Astudillo (REUNA), Jeronimo Bezerra (FIU/AmLight), Matt Kollross (NCSA)

## 2.13 [LVV-90] DMS-REQ-0190-V-01: Archive to Data Access Center Network Reliability

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-90 | Robert Gruendl | Not Covered | 1a | LVV-T202 |

**Verification Element Description:**
This requirement is verified by reconnecting and recovering transfer of data between archive and DACs, after disconnecting fiber at an intermediate location between archive and DACs.

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0190 | |
| Requirement Description | **Specification:** The Archive to Data Access Center communications shall be highly reliable, with MTTR < **archToDacNetMTTR**. | |
| Requirement Parameters | **archToDacNetMTTR = 48[hour]** Mean time to repair, measured over a 1-yr period. | |
| Requirement Priority | 1b | |
| Upper Level Requirement | DMS-REQ-0161 | Optimization of Cost, Reliability and Availability in Order |

### 2.13.1 [LVV-T202] Verify implementation of Archive to Data Access Center Network Reliability

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T202 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**
Reconnect and recover transfer of data between archive and DACs, after disconnecting fiber at an intermediate location between archive and DACs. Verify can meet chToDacNetMTTR = 48[hour]. Demonstrate reconnection and recovery to transfer of data at or exceeding rates specified in LDM-142.

**Precondition:**
Data is staged in LDF and data transfer capabilities to US DAC and Chilean DAC are in place.

**Predecessors:**

PMCS DMTC-8100-2550 Complete

**Test Personnel:**

Ron Lambert (LSST), Albert Astudillo (REUNA), Jeronimo Bezerra (FIU/AmLight), Matt Kollross (NCSA)

## 2.14 [LVV-91] DMS-REQ-0191-V-01: Archive to Data Access Center Network Secondary Link

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-91 | Robert Gruendl | Not Covered | 1a | LVV-T203 |

**Verification Element Description:**
This requirement is verified by reconnecting and recovering transfer of data between archive and DACs, after disconnecting fiber at an intermediate location between archive and DACs.

| Upstream Requirements | | |
|---|---|---|
| Requirement ID | DMS-REQ-0191 | |
| Requirement Description | **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. | |
| Requirement Priority | 1b | |
| Upper Level Requirement | DMS-REQ-0189 | Archive to Data Access Center Network Availability |
| | DMS-REQ-0190 | Archive to Data Access Center Network Reliability |

### 2.14.1 [LVV-T203] Verify implementation of Archive to Data Access Center Network Secondary Link

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T203 | Kian-Tat Lim | Draft | 1 | false | Test |

**Objective:**
FOR EACH SEGMENT (LS - SCL, SCL - FL, FL - CHI, CHI - CHMPGN): Transfer data between base and archive on primary links over uninterrupted 1 day period. Simulate outage by disconnecting fiber on primary and verify that network fails over to secondary links. Transfer data between base and archive over secondary equipment uninterrupted 1 day period. Restore connection on primary link verify that network recovers to primary. Transfer data between base and archive on primary links over uninterrupted 1 day period. Demonstrate transfer of data at or exceeding rates specified in LDM-142 throughout fail-over period except for <=60s fail-over fail-over to secondary and recover to primary connection execution.

**Precondition:**
Data is staged in LDF and data transfer capabilities to US DAC and Chilean DAC are in place.

**Predecessors:**
PMCS DMTC-8100-2550 Complete

**Test Personnel:**
Ron Lambert (LSST), Albert Astudillo (REUNA), Jeronimo Bezerra (FIU/AmLight), Matt Kollross (NCSA)

## 2.15 [LVV-183] DMS-REQ-0352-V-01: Base Wireless LAN (WiFi)

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-183 | Robert Gruendl | Not Covered | 1a | LVV-T192 |

**Verification Element Description:**

At Base Facility, connect to WiFi, test connection speed, i.e. send email, browse web, and retrieve files from the Internet.

| Upstream Requirements | |
|---|---|
| Requirement ID | DMS-REQ-0352 |
| Requirement Description | 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. |
| Requirement Parameters | **minBaseWifi = 1000[megabit per second]** Maximum allowable outage of active DM production. |
| Requirement Priority | 2 |
| Upper Level Requirement | OSS-REQ-0003 The Base Facility |

### 2.15.1 [LVV-T192] Verify implementation of Base Wireless LAN (WiFi)

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T192 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**

Verify (a) plannned and (b) as-built wireless network at the Base Facility supports minBaseWiFi bandwidth (1000 Mbs). Test internet web browsing and file download, email at summit and base over wireless. Verify wireless signal strength meets or exceeds typical, and average and peak bandwidths meet or exceed minBaseWiFI bandwidth.

**Precondition:**

Base Wireless LAN is installed/configured and Test Personnel have accounts for email, internet access.

**Predecessors:**
PMCS DLP-465 Complete.

**Test Personnel:**
Heinrich Reinking (LSST)

## 2.16 [LVV-18491] DMS-REQ-0352-V-02: Base Voice Over IP (VOIP)

| Jira Link | Assignee | Status | Priority | Test Cases |
|---|---|---|---|---|
| LVV-18491 | Robert Gruendl | Not Covered | Undefined | LVV-T181 |

**Verification Element Description:**
Verify (a) plannned and (b) as-built VOIP at the Base Facility is operational and performs as expected (i.e. sufficient number of extensions allocated properly, no frequent drop-outs, no frequent jaggies on video, etc.). Test voice calls and videoconferening.

| Upstream Requirements | |
|---|---|
| Requirement ID | DMS-REQ-0352 |
| Requirement Description | 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. |
| Requirement Parameters | **minBaseWifi = 1000[megabit per second]** Maximum allowable outage of active DM production. |
| Requirement Priority | 2 |
| Upper Level Requirement | OSS-REQ-0003 The Base Facility |

### 2.16.1 [LVV-T181] Verify Base Voice Over IP (VOIP)

| Test Case Suppary | | | | | |
|---|---|---|---|---|---|
| **Jira Link** | **Owner** | **Status** | **Version** | **Critical Event** | **Verification Type** |
| LVV-T181 | Robert Gruendl | Draft | 1 | false | Test |

**Objective:**
Verify (a) plannned and (b) as-built VOIP at the Base Facility is operational and performs as expected (i.e. sufficient number of extensions allocated properly, no frequent drop-outs, no frequent jaggies on video, etc.). Test voice calls and videoconferening.

**Precondition:**
Base VOIP is installed/configured and Test Personnel have phone sets. Base Videoconference system is installed/configured. Summit, Headquarters, and/or LDF Videoconference system is installed/configured.

**Predecessors:**

PMCS DLP-465 Complete

PMCS IT-702 Complete

**Test Personnel:**

Heinrich Reinking (LSST), another LSST DM Person at Summit, Headquarters, or LDF

# A Traceability

| Requirements | Verification Elements | Test Cases |
|---|---|---|
| DMS-REQ-0168 | LVV-71(Gregory Dubois-Felsmann ) | LVV-T1097 (Gregory Dubois-Felsmann ) |
| DMS-REQ-0171 | LVV-73(Robert Gruendl ) | LVV-T1168 (Robert Gruendl )<br>LVV-T1612 (Robert Gruendl ) |
| DMS-REQ-0172 | LVV-74(Robert Gruendl ) | LVV-T185 (Robert Gruendl ) |
| DMS-REQ-0173 | LVV-75(Robert Gruendl ) | LVV-T186 (Robert Gruendl ) |
| DMS-REQ-0174 | LVV-76(Robert Gruendl ) | LVV-T187 (Robert Gruendl ) |
| DMS-REQ-0175 | LVV-77(Robert Gruendl ) | LVV-T188 (Robert Gruendl ) |
| DMS-REQ-0180 | LVV-81(Robert Gruendl ) | LVV-T193 (Robert Gruendl ) |
| DMS-REQ-0181 | LVV-82(Robert Gruendl ) | LVV-T194 (Robert Gruendl ) |
| DMS-REQ-0182 | LVV-83(Robert Gruendl ) | LVV-T195 (Robert Gruendl ) |
| DMS-REQ-0183 | LVV-84(Robert Gruendl ) | LVV-T196 (Robert Gruendl ) |
| DMS-REQ-0188 | LVV-88(Robert Gruendl ) | LVV-T200 (Robert Gruendl ) |
| DMS-REQ-0189 | LVV-89(Robert Gruendl ) | LVV-T201 (Robert Gruendl ) |
| DMS-REQ-0190 | LVV-90(Robert Gruendl ) | LVV-T202 (Robert Gruendl ) |
| DMS-REQ-0191 | LVV-91(Robert Gruendl ) | LVV-T203 (Robert Gruendl ) |
| DMS-REQ-0352 | LVV-183(Robert Gruendl ) | LVV-T192 (Robert Gruendl ) |
| | LVV-18491(Robert Gruendl ) | LVV-T181 (Robert Gruendl ) |

# B References

[1] **[LSE-61]**, Dubois-Felsmann, G., Jenness, T., 2018, *LSST Data Management Subsystem Requirements*, LSE-61, URL https://ls.st/LSE-61

[2] **[LDM-142]**, Kantor, J., 2017, *Network Sizing Model*, LDM-142, URL https://ls.st/LDM-142

[3] **[LSE-78]**, Lambert, R., Kantor, J., Huffer, M., et al., 2017, *LSST Observatory Network Design*, LSE-78, URL https://ls.st/LSE-78

[4] **[LSE-160]**, Selvy, B., 2013, *Verification and Validation Process*, LSE-160, URL https://ls.st/LSE-160

# C Acronyms

| Acronym | Description |
|---|---|
| BDC | Base Data Center |
| BERT | Bit Error Rate Tester |
| CCS | Camera Control System |
| CHI | Chicago |
| CHMPGN | Champaign (Illinois) |
| CISS | Computer Infrastructure Services South (part of the former NOAO Cerro Tololo Inter-american Observatory (CTIO), now merged into NSF'S OIR Lab Central Operating Services) |
| CTIO | Cerro Tololo Inter-American Observatory |
| DAC | Data Access Center |
| DAQ | Data Acquisition System |
| DM | Data Management |
| DMCS | Data Management Control System |
| DMS | Data Management Subsystem |
| DMS-REQ | Data Management top level requirements (LSE-61) |
| DMSR | DM System Requirements; LSE-61 |
| DMSSIT | DM Subsystem Integration Test |
| DMTR | DM Test (Plan and) Report |
| DTN | Data Transfer Node |
| DWDM | Dense Wave Division Multiplex |
| EFD | Engineering and Facility Database |
| EPO | Education and Public Outreach |
| FIU | Florida International University |
| FL | Florida |
| HL | Higher Level |
| IP | Internet Protocol |
| ISO | International Standards Organization |
| IT | Information Technology |
| LAN | Local Area Network |
| LATISS | LSST Atmospheric Transmission Imager and Slitless Spectrograph |
| LDF | LSST Data Facility |
| LDM | LSST Data Management (Document Handle) |

| | |
|---|---|
| LHN | Long-Haul Networks |
| LL | Lower Level |
| LS | La Serena |
| LSE | LSST Systems Engineering (Document Handle) |
| LSST | Large Synoptic Survey Telescope |
| LVV | LSST Verification and Validation (Jira project) |
| MTBF | Mean Time Between Failures |
| MTTR | Mean Time to Repair |
| NCSA | National Center for Supercomputing Applications |
| NET | Network Engineering Team |
| OCS | Observatory Control System |
| OSI | Open System Interconnect |
| OSS | Observatory System Specifications; LSE-30 |
| OTDR | Optical Time Domain Reflectometer |
| PMCS | Project Management Controls System |
| REUNA | Red Universitaria Nacional |
| SC | Science Collaboration |
| SCL | Santiago, Chile |
| SIT | LSST System Integration Test |
| SL | Same Level |
| SLAC | SLAC National Accelerator Lab |
| TCS | Telescope Control System |
| US | United States |
| VNVD | Vera C Rubin Observatory Network Verification Document |
| VOIP | Voice Over Internet Protocol |
| WBS | Work Breakdown Structure |