Large Synoptic Survey Telescope (LSST) 
Observatory Control System (OCS) 
Requirements 

German Schumacher and Francisco Delgado 

LSE-62 (rel6.0) 
Latest Revision: May 11, 2018 

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# Change Record

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<td>11/16/2016</td>
<td>Implementation of LCR-745 and LCR-746</td>
<td>K. Wesson and F. Delgado (SysML &amp; docGen), R. McKercher (DocuShare)</td>
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<td>Administrative change. No content change. Still release</td>
<td>K. Wesson</td>
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<td>2017-11-6</td>
<td>Implemented LCR-1015 to remove duplicate IDs. Implemented LCR-1120 splitting of multiple shall statements, clarifications of discussions, and ensuring requirements are verifiable. No major scope additions or updates have been made.</td>
<td>K. Wesson, Andrew Serio</td>
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<tr>
<td>6.0</td>
<td>2018-05-11</td>
<td>Implemented LCR-899 promoting scheduler requirements to a system level controlled document.</td>
<td>C. Claver (LCR), T. Ribeiro (LCR), R. Carlson (SysML)</td>
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The LSST Observatory Control System (OCS) Requirements

Introduction

The Observatory Control System (OCS) is the master control system that commands, coordinates, and monitors the observatory. The OCS is responsible for high level observatory operations including user interfaces, sequencing, resource allocation and system monitoring and maintenance. The OCS orchestrates and controls all aspects of the observatory for all observations (science, calibration, and engineering) and all operation modes. The OCS coordinates the camera, telescope, data management subsystems for an integrated operation during the survey. Through the OCS the system can be started, monitored, adjusted during operations and stopped, both locally and remotely. The OCS provides the means to support safe observatory operations during day and night.

Document Scope:

The OCS Requirements document describes high-level specific requirements for the observation operational support to be implemented by the Observatory Control System, and it is derived from the Observatory System Specifications document (LSE-30) and from the Operations Simulator survey baseline document.

Supporting Documents

LSST Science Requirements Document (LPM-17)
LSST System Requirements (LSE-29)
LSST Observatory System Specifications (LSE-30)
LSST Document Tree (LSE-39)

Definitions 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.
The LSST Observatory Control System (OCS) Requirements

1 OCS Performance Requirements

The OCS contributes to the performance of the observatory by coordinating the subsystems efficiently in all observation modes.

1.1 OCS Unscheduled Downtime

ID: OCS-REQ-0057

**Specification:** The OCS subsystem shall be designed to facilitate unplanned repair activities expected not to exceed a suballocation of $TSUnSchDowntime$ days per year.

**Discussion:** For the purpose of design and construction, unscheduled downtime requirements have been allocated based on work packages where the OCS is a part of the Telescope and Site. This principle is reflected in the negotiated T&S allocation found in LCR-188. The T&S subsystem will work with the OCS to determine the appropriate OCS allocation from the TSUnSchedDowntime allocation specified in TLS-REQ-0150. 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.

1.2 Null Overhead

ID: OCS-REQ-0058

**Specification:** The OCS control activities shall not add overhead time to the operation of the observatory.

**Discussion:** All the eventual time-consuming OCS activities will be performed in advance to the actual observations and in parallel to the already defined sequence of activities. The commanding and telemetry traffic delays will be negligible in comparison to the control time constants of the subsystems.

1.3 Communications Performance

ID: OCS-REQ-0061

**Specification:** The OCS middleware communications performance shall comply with a latency of less than $ocsMsgLatency$, a throughput of at least $ocsMsgRate$, and a data persistence of at least $ocsMsgPersistence$.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>The message transmission in the OCS middleware has a</td>
<td>300e-6</td>
<td>second</td>
<td>$ocsMsgLatency$</td>
</tr>
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</table>
2 OCS Maintenance Requirements

The OCS will support the maintenance activities of the observatory, capturing and storing telemetry, coordinating routine maintenance operations and providing interfaces to the users to evaluate and perform maintenance jobs.

2.1 Maintenance Planning

ID: OCS-REQ-0054

Specification: The OCS shall support the planning of maintenance activities to perform preventive maintenance in order to achieve the reliability goals of the system.

Discussion: The outcome of the planning activities will be a report with the proposed job(s) to be performed at the observatory.

2.2 System Maintenance

ID: OCS-REQ-0055

Specification: The OCS shall provide the tools to support the scheduled maintenance jobs originated as a result of the planning activities.

Discussion: The support comprises the coordination of the subsystems in activities like, getting a new pointing model set of parameters in the TCS with the computations from the DM.

2.3 Analysis

ID: OCS-REQ-0052

Specification: The OCS shall provide tools for the analysis of telemetry and state information in order to optimize the system and to measure performance trends over long periods.

Discussion: The analysis tool set is intended to be flexible and expandable, to cope with specific demands from the subsystems. The subsystems may develop extensions using the infrastructure provided by the tool like EFD access and report and graphics generation.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>latency of less than</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The message persistence of a particular parameter in the OCS middleware is of at least</td>
<td>2</td>
<td>integer</td>
<td>ocsMsgPersistence</td>
</tr>
<tr>
<td>The OCS middleware has the capacity of handling messages at a rate of at least</td>
<td>50e3</td>
<td>hertz</td>
<td>ocsMsgRate</td>
</tr>
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</table>

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2.4 Maintenance Log

**ID:** OCS-REQ-0053

**Specification:** The OCS shall maintain a log of all the maintenance activities. The OCS shall provide an interface to manually generate the complimentary maintenance information that it is not possible to obtain through the telemetry. This interface shall also allow to obtain and analyse the information about the maintenance activities performed in every subsystem.

3 OCS Functional Requirements

The functional requirements comprise the operations and behaviour that the OCS implements to accomplish the data collection capabilities of the observatory.

3.1 Observations

3.1.1 Perform Observations

**ID:** OCS-REQ-0002

**Specification:** The OCS shall orchestrate the complete set of subsystems in the observatory to perform observations.

**Discussion:** An Observation is the sequence of target definition and validation, telescope and camera setup operations, the exposure for a certain time and the corresponding data delivery. These observations can be originated by a manual request, or by an automatic mechanism.

The OCS coordinates the subsystems in all the phases of an observation, such as configuration, slew, exposure, readout and storage of the image frames and the metadata. The Observing Modes are to be selectable by an operator.

3.1.1.1 Science Observation

**ID:** OCS-REQ-0003

**Specification:** The OCS shall orchestrate the execution and acquisition of science data from the observatory.

**Discussion:** The prime role of the OCS is to efficiently orchestrate the acquisition of the science images and telemetry data from the observatory at all times of the night.

3.1.1.2 Calibration Observation

**ID:** OCS-REQ-0004

**Specification:** The OCS shall orchestrate the acquisition of calibration data from the observatory.

**Discussion:** For acquiring calibration data, the OCS coordinates additional hardware that is not normally utilized for regular science observations.
3.1.1.3  Engineering Observation

ID: OCS-REQ-0005

**Specification:** The OCS shall orchestrate the execution and acquisition of engineering data from the observatory.

**Discussion:** This data is associated to the maintenance plan developed for the observatory.

3.2  Survey

3.2.1  Support Survey

ID: OCS-REQ-0006

**Specification:** The OCS shall control all the subsystems to conduct a survey over **Asky** area of sky; with a median depth of **Nv1Sum**, using **FC** filters during a life time of **surveyTime**.

**Discussion:** The parameter **Asky** is defined in LSR-REQ-0098 as 18000 Square Degrees.

The parameter **Nv1Sum** is defined in LSR-REQ-0098 as 825 visits.

The parameter **FC** is defined in LSR-REQ-0082 as ugrizy.

The parameter **surveyTime** is derived from OSS-REQ--0097 as 10 years.

The cadence of visits and filter usage distribution is determined by the science programs demands handled by the Scheduler sub-component of the OCS. Final priorities are set by a survey overseers committee.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Unit</th>
<th>Name</th>
</tr>
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<tbody>
<tr>
<td>The total area of sky covered by the median number of visits shall be no less than</td>
<td>18000</td>
<td>degree squared</td>
<td>Asky</td>
</tr>
<tr>
<td>The ugrizy filter set is based on the filters from the SDSS with the addition of the y-band, These provide roughly uniform sampling of the optical spectrum from 320-1000nm.</td>
<td>ugrizy</td>
<td>unitless</td>
<td>FC</td>
</tr>
<tr>
<td>The median number of visits for each place of the sky within the main survey area shall be at least</td>
<td>825</td>
<td>visit</td>
<td>Nv1Sum</td>
</tr>
<tr>
<td>Survey operations</td>
<td>10</td>
<td>year</td>
<td>SurveyTime</td>
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3.2.1.1  Schedule Survey

ID: OCS-REQ-0007

**Specification:** The OCS shall contain an automatic Scheduler sub-component, which organizes the outstanding observations in a way that optimizes observing time and achievement of the specified science goals.
**Discussion:** The Scheduler sub-component is responsible for processing of the telemetry stream and the encoded scientific objectives to provide an observing queue. The Scheduler requirements are defined in a separate document.

### 3.2.1.2 Observations Database

**ID:** OCS-REQ-0018

**Specification:** The OCS shall keep a detailed observations database with the complete history of observations with their parameters and environmental conditions under which they were taken.

**Discussion:** This observations database may be used for ranking future visits and also for building automatic and on-demand reports about the survey progress, globally and for each science program.

### 3.2.1.3 Image Processing Control

**ID:** OCS-REQ-0021

**Specification:** The OCS shall inform the Data Management System in advance of the image acquisition of the needed processing related the specific image type.

**Discussion:** This requirement ensures that the Data Management operating at the Base Facility has advance notice of the type of image(s) that are being acquired. This is to inform the Data Management system of the type of processing it needs to perform on the images as they are obtained.

### 3.2.1.4 Survey Lifetime

**ID:** OCS-REQ-0022

**Specification:** The OCS shall support the observatory operations for the length of the 10 years survey (surveyTime).

### 3.2.1.5 Survey Verification

**ID:** OCS-REQ-0060

**Specification:** The OCS shall support the commissioning phase of the construction, and the science verification phase prior to the survey.

### 3.3 Operational Requirements

The OCS will support different behaviours to accommodate several operating scenarios depending on survey specifications and present conditions.

#### 3.3.1 Operation Control

**ID:** OCS-REQ-0026

**Specification:** The OCS shall be capable of commanding each subsystem of the data collection process of the observatory, to perform the requested observations or operational procedures.
3.3.1 Hierarchical Control

ID: OCS-REQ-0027

Specification: The OCS shall be capable of commanding the subsystems in a hierarchical way. Each subsystem, Telescope Control System (TCS), Camera Control System (CCS) and Data Management System (DMS) must have a command interface for OCS and provide its status in a detailed level.

Discussion: See the ICD documents LSE-70, LSE-74, LSE-71, LSE-72 and LSE-73 for a detailed description of commands and status exchanges.

3.3.2 Observing Mode

ID: OCS-REQ-0028

Specification: The OCS shall support different modes of observations, according to the established observing plans.

3.3.2.1 Scripted Observation

ID: OCS-REQ-0031

Specification: The OCS shall support sequencing of observations through user specified scripting of the sequence that are safe and repeatable.

Discussion: This requirements supports the needs anticipated during commissioning, establishing calibration sequences, and engineering and maintenance operations.

3.3.2.2 Manual Observation

ID: OCS-REQ-0030

Specification: The OCS shall have the capability to perform manual observations, requested by an operator.

3.3.2.3 Automated Observation

ID: OCS-REQ-0029

Specification: The OCS shall provide the capability to perform automated observations in a safe and repeatable way.

3.3.2.4 Control Mode

ID: OCS-REQ-0065

Specification: The OCS shall be capable of being operated in a local and global configuration.

3.3.2.5 User Coordinated Observation

ID: OCS-REQ-0067

Specification: The OCS shall coordinate the devices in the subsystems according to the manual
instructions given by the user to perform the requested observation or sequence of observations.

### 3.3.2.6 Device Coordination

**ID:** OCS-REQ-0068

**Specification:** The OCS shall coordinate all subsystem devices involved in an observation, or sequence of observations, in a repeatable and safe way.

### 3.3.3 Summit Operation

**ID:** OCS-REQ-0033

**Specification:** The OCS shall provide the interfaces to operate the observatory from the control room in the summit.

### 3.3.4 Remote Operation

**ID:** OCS-REQ-0034

**Specification:** The OCS shall provide the interfaces to operate the observatory from the designated remote locations.

### 3.3.5 User Interface

**ID:** OCS-REQ-0035

**Specification:** The OCS shall provide interfaces for users to interact with its functionality.

**Discussion:** Through the user interface, the system can be started, monitored, adjusted during operations and stopped, both locally and remotely.

#### 3.3.5.1 GUI

**ID:** OCS-REQ-0038

**Specification:** The OCS shall provide graphical and command line interfaces to facilitate the observatory operations.

#### 3.3.5.2 Displays

**ID:** OCS-REQ-0037

**Specification:** The OCS shall provide displays of system-wide state information.

#### 3.3.5.3 Access Control

**ID:** OCS-REQ-0036

**Specification:** The OCS shall control the access to the user interfaces with an authentication mechanism.

### 3.3.6 Change of subsystem state without failure

**ID:** OCS-REQ-0059
**Specification:** The OCS shall not fail if a subsystem unexpectedly changes state, does not respond or otherwise fails to operate as required.

**Discussion:** The OCS will issue messages to the other subsystems to notify of this change of state or failure in order to protect other subsystems from such a condition.

### 3.3.7 Graceful degradation

**ID:** OCS-REQ-0039

**Specification:** The OCS shall enable the observatory to continue the survey in a gracefully degraded mode in case of subsystems failures that still allow the acquisition of useful data.

**Discussion:** When a device in a subsystem is in failure, the OCS disables that device and takes the needed actions to communicate that state change to all subsystems. For instance, the Scheduler may be configured to operate at different levels of degraded mode and take that information into account when ranking targets.

### 3.3.8 Safety

**ID:** OCS-REQ-0040

**Specification:** The OCS shall follow the safety policies established by the Observatory System Specifications (OSS-REQ-0098).

**Discussion:** The status of the safety system must be monitored by the OCS. Unsafe conditions must be reported directly to the observatory operators as well as logged by the OCS. No part of the OCS is allowed to be part of or interfere with, any observatory safety systems.

#### 3.3.8.1 Safety Procedures

**ID:** OCS-REQ-0043

**Specification:** The OCS shall enforce the application of safety procedures in the observatory operations.

#### 3.3.8.2 Interlock System

**ID:** OCS-REQ-0041

**Specification:** The OCS shall follow the state of an external interlock system to abide for a safe operating environment.

### 3.4 Observatory Services

The OCS provides services of common use observatory-wide, in order to optimize the use of information technologies.

#### 3.4.1 Middleware Communications

**ID:** OCS-REQ-0049

**Specification:** The OCS shall implement a middleware communications layer to allow the commanding and telemetry capture to all subsystems.
Discussion: The baseline architecture of this middleware is based on the publish/subscribe protocol, as defined by the Data Distribution Service (DDS) standard. The communications backbone runs on top of the Observatory network infrastructure.

3.4.2 System Monitor

ID: OCS-REQ-0050

Specification: The OCS shall provide the means for a continuous system monitoring, during night time as well as day time, giving support for the science, calibration and engineering observations, status and activities, also facilitating the handover of the system between users in different work shifts.

Discussion: One of the important monitoring functions is a comprehensive handling of events incorporated into the telemetry stream, logged as a component of the EFD.

3.4.3 Engineering Facility Database

ID: OCS-REQ-0046

Specification: The OCS shall capture, organize and store system-wide, time tagged state information to make it available for monitoring, evaluation and calibration processes.

Discussion: This section will implement the requirements on the functionality and performance of the Engineering and Facility Database (EFD) as it relates to the Telescope, Camera, Data Management and Calibration operations. This includes (but is not limited to) telemetry ingestion, replication of the EFD at Base and Archive sites, support of queries and instantiation of the EFD during the development phase of the subsystems.

This telemetry and observatory condition information will be distributed to support both local and remote operations in an efficient manner.

3.4.3.1 Persistence of Telemetry

ID: OCS-REQ-0048

Specification: The EFD shall persist all published observatory telemetry generated by the OCS, telescope, camera and data management subsystems.

Discussion: In particular, up to the defined limits in OSS -REQ-0311 and replicated here, all published telemetry is captured reliably by the EFD, permanently.

<table>
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<th>Value</th>
<th>Unit</th>
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<td>Long-term mean ingest rate to the Engineering and Facilities Database of non-science images required to be supported.</td>
<td>15.4</td>
<td>megabit per second</td>
<td>Blob_AvgRate</td>
</tr>
<tr>
<td>Long-term mean ingest rate to the Engineering and Facilities Database required to be supported.</td>
<td>6.5</td>
<td>megabit per second</td>
<td>EFD_AvgRate</td>
</tr>
<tr>
<td>The minimum supported daily data volume of the engineering</td>
<td>30</td>
<td>gigabyte</td>
<td>EFD_DayStore</td>
</tr>
</tbody>
</table>
### 3.4.3.2 Availability of EFD contents

**ID:** OCS-REQ-0047

**Specification:** All EFD contents shall be available for queries not impacting real time subsystems activities.

**Discussion:** A complex query like "raft 13 temperatures for past 2 years" may span EFD instances at mountain, base, and archive and/or access centres. Such access must be user transparent. The performance of a query processing is subject to a quality of service assignment.

### 3.4.4 Subsystem Latest Configuration

**ID:** OCS-REQ-0045

**Specification:** The Configuration Database shall manage the latest configuration for each subsystem, for the different observing modes.

**Discussion:** The Configuration Database maintains also the latest configuration utilized during operations that can be utilized for rapid restoration of service, in case of failure.

#### 3.4.4.1 Subsystem Parameters

**ID:** OCS-REQ-0069

**Specification:** The Configuration Database shall manage the subsystem parameters for the different observing modes.

#### 3.4.4.2 Subsystem History

**ID:** OCS-REQ-0070

**Specification:** The Configuration Database shall manage subsystem history for the different observing modes.

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