LARGE SYNOPTIC SURVEY TELESCOPE

DM Science Verification: Definition, Scope, and Organization

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reference: DM-mjuric-01-1D
issue: 1D
revision: 1
date: 2017-02-20
status: draft

Abstract

In this document we lay out the scope and organizational concepts of the LSST **Data Management Science Verification** (DM SV) effort. We define Science Verification as *the assurance that the Data Management system meets the needs of the scientific community and other identified stakeholders*.

This documents defines the scope of the SV work, the deliverables, the breakdown of work, as well as assigns responsibilities for DM-specific SV within the DM Organization.

Document History

Issue	Revision	Date	Author	Comment
D	1	2017-02-17	MJ	First draft

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1 Introduction

1.1 Scope

This document describes the scope and organizational concepts of the **LSST Data Management Science Verification** (DM SV) effort.

1.2 Background and Motivation for the Activity

LSST Data Management subsystem is charged with delivering a fully functional Data Management system capable of generating and serving to the community the LSST data products as defined in the Science Requirements Document (SRD). This overall mission has been flowed down to the requirements and design of DM components and services, as described in the DM branch of the project work breakdown structure (02C.02.*) and design document referenced therein.

Assuming idealized conditions, once the project goals have been unambiguously articulated and flowed down to (quantitative) definitions of requirements, once those requirements have been validated to satisfy the mission need, once design has been established to implement the requirements, and once the plan has been established to build, integrate, and verify the components and the system as a whole, it could be theoretically possible to build and integrate the DM system by strictly adhering to the plan and and verifying the as-built system against the original requirements only[1].

Reality tends to settle from ideal conditions. The definition of the mission may not be sufficiently clear at the beginning of the project (or may change). The flow-down of requirements may contain errors or not fully capture the metrics relevant to scientific success of the mission. The assumptions made while deriving requirements and designs may not be born out by the real data. Similarly, designs are possible that satisfy formal requirements, but deliver unsatisfactory solutions that would impede research with LSST (e.g., systems that are too complex). Or designs may make suboptimal trades (e.g., would require expenditure of significant resources to perfect features that are by then recognized as unneeded).

A way to ensure that what's being built does not diverge from the ultimate goals (as their understanding evolves and improves) is to periodically exercise the integrated system as it's being built beyond piece-wise requirements verification and, ultimately, with real data. I.e., *try to use it in ways we would expect it to be used by the stakeholders – the ultimate users of the system – scientists*. Such exercises close the design-build-verify loop, and enable one measure the degree to which the requirements, designs, and plans continue to satisfy stakeholder needs. Furthermore, they provide valuable feedback about modifications needed to ensure the delivery of a scientifically capable system.

[1] This is, roughly, the *waterfall model* of development.

1.3 Objectives

The primary objective of this document is to define mechanisms by which we will periodically verify that the DM system, as a whole, is on track to being capable to acceptably support the science goals of commissioning and operations: **DM Science Verification**.

We define **DM Science Verification** as **the assurance that the Data Management system meets the needs of the scientific community and other identified stakeholders**. This follows the PMBOK 4th ed. definition of *validation*[2,3]

The solutions described below are a response to the responsibilities and authorities delegated to the DM Project Scientist by R2A2 documents for the LSST organization (LPM-???), and draw heavily on the Commissioning Plan, as well as the Operations Plan.

1.3.1 Science Verification

To discuss DM Science Verification (SV), we coarsely break down and define some aspects of Construction and Integration and Test procedures and how they come together to ensure a functioning system is delivered. While we roughly define the roles and responsibilities for all parts of that process, we do not dwell on the details of non-SV elements, namely *verification*; these are beyond the scope of DM Project Science. This document focuses on Science Verification – other elements are sketched out as necessary to understand the scope and execution of SV.

A schematic overview of the iterative process by which the LSST Data Management system is built is shown in Figure 1. The cycle duration is roughly ~ 6 months. Deliveries are represented by single-headed arrows connecting the three boxes in the lower part of the diagram. Each arrow presumes *a battery of verification tests have been run* before the deliverables were handed over to the next stage.

We (conceptually) divide the process into three stages:

- **Component Construction**: The LSST WBS establishes that construction partner institutions are responsible for delivering feature-complete, tested, documented, work packages[4]. As such, upon hand-over to I&T, the *partner institutions are responsible for demonstrating that their deliverables meet agreed upon requirements.*. These tests, developed by the partner institutions, will generally go beyond simple unit tests; the expectation is that the delivered components will perform as expected at their level of maturity when fed LSST-like data. While they can (and should) rely on an automated QC system to automate and execute these tests, the responsibility for devising and writing them is

[2]It would have been more appropriate to name this activity *Science Validation*; however, given the established use of the term *Science Verification* on LSST and other large projects in the U.S. (e.g., DES, DESI, ALMA), we will continue to use it.

[3]`https://en.wikipedia.org/wiki/Verification_and_validation`

[4]It's typical for an entry in the Work Package notebook to begin with "*This WBS element includes software programs, configuration files, unit tests, component integration tests, and documentation that implement Foo...* "; See LPM-44 for details.

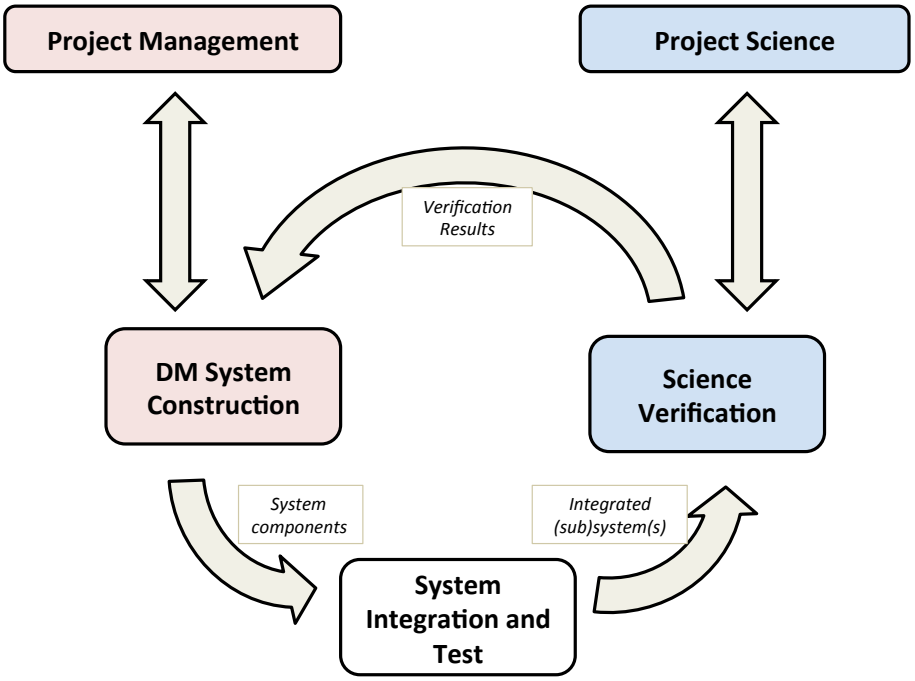

FIGURE 1: A graphical representation of the feedback loop from Science Verification

with the partner institution. Testing standards and procedures are described in a separate document (LDM-50x??).

- **Integration and Test**: The operating institution (generally, NCSA) is responsible for taking deliverables from the construction partners and integrating them into increasingly capable and more integrated prototypes of the DM System. NCSA will, as a part of Integration and Test, run a battery of quality assurance tests verifying against requirements the functioning of the as-built system, and preventing unexpected regressions relative to prior releases. High level of integration of this and the automated QC system mentioned above would be advantageous; optimally, the I&T of software components would be fully automated and continuous.
- **Science Verification**: The integrated prototypes of parts or the whole DM system are delivered to the DM Project Science Group for Science Verification. The PSG devises and performs additional tests and data challenges to exercise the integrated system and assess its quality relative to expectations for the current phase of construction. This assessment is fed back to DM Project Science, Management, and Architecture, to inform future development of the system. The QA tests or procedures identified as good metrics of system quality are also fed back to the I&T team for incorporation into the automated QC systems, to be run in the I&T or Component-level QA phases in the future, as appropriate.

An example of this process may be as follows:

- At the end of a 6-month cycle, Princeton University delivers to NCSA a documented and

internally tested set of DRP pipelines with a well defined list of capabilities (for example, the Multifit implementation of the moving point source model – i.e., proper motions and parallax measurements). The pipelines pass all unit and small-scale integration tests.

- NCSA deploys and re-verifies the received pipelines in the I&T environment designed to closely mimic the production environment[5]. They verify that the pipeline integrates well with the NCSA-delivered orchestration system and is capable of executing medium-to-large scale processing. The pipelines pass integration tests.

- With input from DM Project Management, the Science Verification team designs, organizes, and coordinates a data challenge to stress the new capabilities. For example, a mini data release production using HSC data could be devised to independently validate the proper motion measurements beyond what is already included in the QC and I&T tests. The challenge is executed by the proto-Operations team (e.g., the group at NCSA who will execute the data release production in operations). The analysis from the end-user perspective is performed by the SV team. The results and conclusions derived from the data challenge are fed back to the DRP team, DM Project Management, and DM Project Science; they may be used to assess the overall quality of the product, pass a formal requirement, and/or inform future construction decisions. Any newly developed but broadly useful tests are identified as such, and fed to the I&T team for inclusion into the battery of tests that are run on a regular basis.

2 Organization, and Schedule

2.1 Organization

The DM Project Scientist is accountable to the LSST Project Scientist for the success of DM Science Verification activities. They delegate the responsibility for the coordination of Science Verification activities to the DM Science Verification Scientist[6]. SV activities draw on resources of the DM Project Science Group[7] (Figure 2), but may also tap into the broader construction team if needed (and as jointly agreed upon with the DM Project Manager), as well as contributors from the LSST Science Collaborations. Decisions on strategic goals of SV exercises are made in close consultation and coordination with the DM Project Manager; for example, it would be expected that the SV team would be downstream of dress rehearsal activities, receiving any generated data.

Participants in SV activities make up the Science Verification Team. The team is lead by the DM SV Scientist. The SV Scientist, the DM Science Pipelines Scientist, and all Team Project Scientists are ex-officio members of the SV Team. DM Project Scientist and Managers are not

[5]Nothing in this precludes a DevOps-like design (e.g. see https://en.wikipedia.org/wiki/DevOps) of this element of the system; it would be desirable if these kinds of deployments were maximally automated.

[6]This position has previously been called the "End-to-end Scientist"; the change has been made to harmonize the terminology with the Commissioning Plan where analogous activities take place using real LSST data.

[7]Our first choice would be to call this group the DM Project Science Team, consistent with the terminology elsewhere in DM, but because of potential confusion with the project-level *Project Science Team* we choose the title "Group"

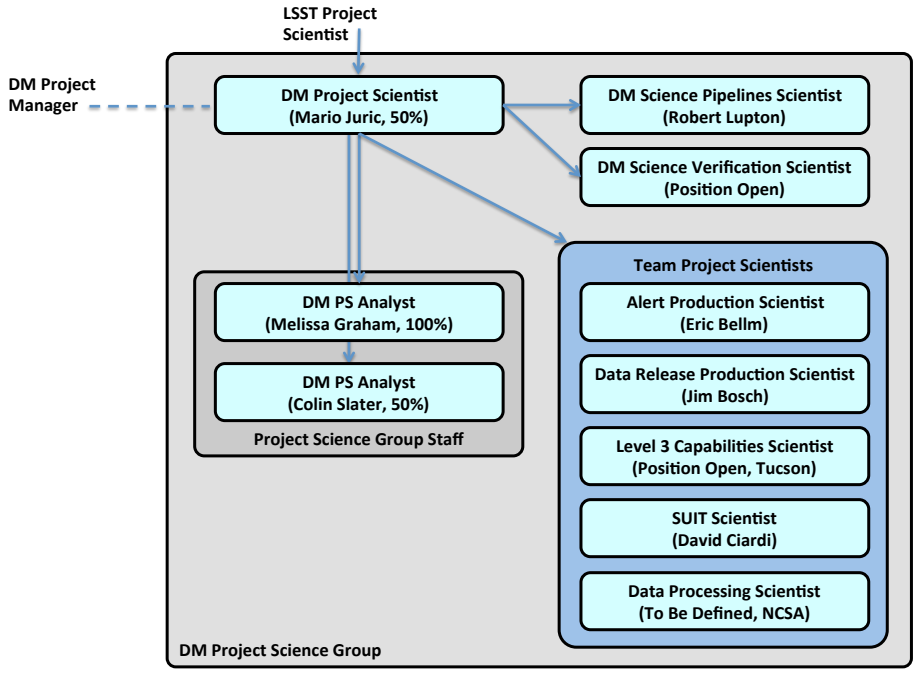

FIGURE 2: Organogram of the Data Management Project Science Group. DM Science Verification is the responsibility of the Project Science Group, coordinated by the Science Verification Scientist.

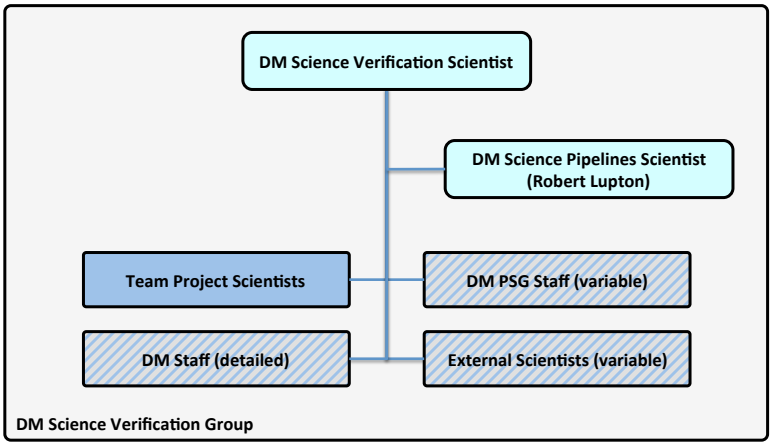

FIGURE 3: Organogram of the Data Management Science Verification Group. The group is chaired and coordinated by the DM Science Verification Scientist, with the DM Science Pipelines Scientist and Team Project Scientists making up the permanent membership. Depending on the SV activities being executed at any given time, the group may draw on additional temporary members from DM PSG Staff, the broader DM Construction staff, as well as external scientists (e.g., Science Collaboration members committed to assisting SV goals). SV membership is reassessed on a cycle by cycle basis, with estimates incorporated in the long-term plan.

formal members, but monitor the work of the group. Additional members may added as needed, depending on SV activities being considered and based on the recommendation of the DM SV Scientist and resource constraints. This is illustrated in Figure 3.

2.1.1 Stakeholders

DM Project Scientist commissions and accepts the results of SV activities. The results (reports) are used to inform actions of the DM Project Science Group (as Product Owners) while articulating DM development priorities and maintaining the overall DM system vision.

The DM PS informs the **DM Project Management** of SV results and recommendations. The DM Project Manager can use these to assess current development status, measure performance, make development adjustments, and generally enhance their awareness of the actual state of the system relative to the plan.

The DM PS reports the results and recommendations to the **LSST Project Scientist**. The LSST PS uses the reports to maintain awareness of the status and progress of the LSST Data Management subsystem, as well as direct the activities of the DM Project Scientist.

2.1.2 Transition to Updated Organization

At the moment, the SQuaRE scientist holds responsibilities closest to those of the DM SV Scientist role. Following the departure of David Nidever, this position is currently open, with Michael Wood-Vasey (U. Pitt) serving in an interim role at 25%.

Following the adoption of this document, the SQuaRE scientist responsibilities will be reassigned to two new positions:

- **Level 3 Scientist**: with the responsibility to serve as the Product Owner for the Level 3 services aspects of the LSST Science Platform (and possibly other areas), and
- **SV Scientist**: with the responsibility to lead and coordinate the work of the DM Science Verification group, as described in this document.

Some responsibilities presently delegated to the SQuaRE scientist, such as collection and curation of science verification datasets, or the definitions of code modules to measure the very high-level key performance metrics (KPMs), will revert to the Project Science Group (and be specifically delegated to designated staff). For example, KPMs measuring the quality of DRP-derived products (e.g., TEx measures of PSF correlations) are most naturaly owned by the DRP Scientist as the Product Owner in that area. This has already partly taken place.

These activities are integral to the SV aspect of DM Project Science role, but will obviously greatly assist CI and I&T activities. The collection and curation of datasets and execution of metrics will be done in close collaboration with the DM Construction team. I.e., it should utilize the same tooling, databases, etc. that the Construction team provide and use for I&T

themselves. The systems on which SV will be performed, and the (e.g., visualization) widgets used, will be developed by the DM Construction team.

2.1.3 Evolution into Commissioning

[[TO BE WRITTEN (basically, the SV team (and all of its tools and processes) continue into commissioning – the nature of the work is qualitatively the same). **We're effectivelly building the Commissioning SV team here, that Chuck & Zeljko smoothly inherit in ∼2020**. Chuck will be at UW next week to make sure this responds to the needs of the Commissioning Plan.]]

2.1.4 Evolution into Operations

[[TO BE WRITTEN (some in the SV team may join the Science Ops team, making it possible to smoothly transfer experience and expertize to the new LSST Center).]]

2.2 Schedule

DM SV activities are planned and prepared in a rolling wave fashion in parallel with development activities (on a 6-month cycle, or perhaps a year). The SV activities will typically be designed so as to exercise the capabilities of the system expected to be delivered at the end of a given development cycle. There shall exist a long-term roadmap of SV activities, linked to product delivery milestones in the DM's Construction Plan. The definition and design of SV activities will be performed in close consultation with the DM Project Manager.

By their nature, SV activities will typically lag behind deliveries of the (sub)system being verified – ideally, they will commence immediately upon delivery. Preparatory SV activities (e.g., identification and acquisition of suitable datasets, identification of potential Science Collaboration resources to include on the activity, or development of activity-specific analysis codes) will commence as early as feasible. DM SV Scientist will coordinate the execution of all SV activities.

SV activities should aim to take no longer than two months to conclude, to enable rapid actionable feedback to DM Management and DM Project Science.

3 Work to be performed

The Project Science Group will design and execute SV activities to assure that the Data Management system meets the needs of the scientific community and other identified stakeholders as described in the previous section.

3.1 Project Management, Reporting and Meetings

3.2 Management

The DM Project Scientist will be accountable for the execution of Science Verification activities. They delegate their responsibility in the area to the **DM SV Scientist**.

The DM SV Scientist will be responsible for proposing, planning, and executing all SV activities. The SV Scientist will be the CAM for the account out of which SV activities are funded.

3.2.1 DM SV Scientist: R2A2 Breakdown

[[TO BE WRITTEN]]

3.3 Reporting

DM SV Scientist will regularly report on the status of SV activities to the DM Project Scientist.

The DM Project Scientist will regularly inform the DM Project Manager and the LSST Project Scientist of the status of ongoing SV activities.

All SV activities will conclude with a written report, accepted by the DM Project Scientist. The SV Scientist is responsible for the writing and submission of the report.

3.4 Meetings and Travel

The SV Team will meet via video as often as needed to ensure the success of SV activities.

The SV Team members will travel for in-person meetings as needed to ensure the success of SV activities, within the constraint of the available travel budget.

4 Deliverables

Key deliverables of Science Verification activities are:

- Reports on the measured capability of the Data Management System to satisfy stakeholder needs. The assessments shall take into account the expected maturity of the system being tested.
- Recommendations for improvements and changes, both in the quality of as-constructed systems (i.e., what needs to be built differently or better, to make it more consistent with the system vision) as well as the overall system vision (i.e., where the vision needs to be changed to better address stakeholder needs).

- Measurements of performance metrics that do not lend themselves to easy automation (e.g., science activities requiring human involvement, like visual classification, or UX tests). Development of new performance metrics, including potential deliveries of code to the DM Construction and I&T teams for inclusion in automated pipelines.
- Other deliverables as charged when chartering a particular SV exercise.

5 Deliveries to the SV Team

The DM I&T team shall deliver to the DM SV team the system or systems being tested, that have already passed formal requirements verification to the degree agreed upon when the SV activity was chartered[8].

The DM Construction team shall deliver to the DM SV team the quality assessment tools and widgets (e.g. JupyterHub system with access to prototype data products, or visualization widgets used to explore LSST data) needed for successful execution of the SV effort.

[8] We leave this caveat to make room for formal activities which themselves may be verified by the SV activity.