Vera C. Rubin Observatory
Rubin Observatory Operations

# Criteria to start the Legacy Survey of Space and Time

**Robert Blum, Željko Ivezić, Phil Marshall**

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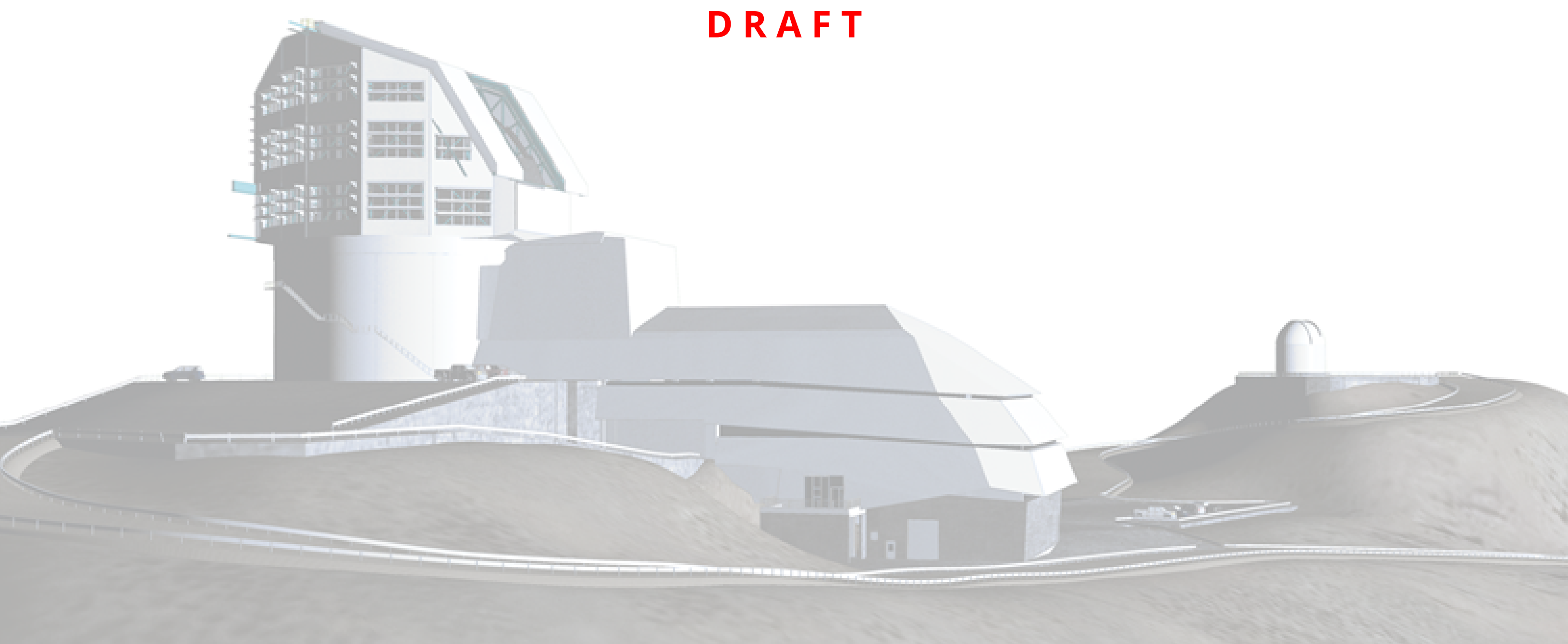

## Abstract

This document concisely captures the criteria that must be satisfied to begin regular survey operations for the Legacy Survey of Space and Time (i.e. to being execution of the planned 10 year survey strategy currently documented in pstn-056). It is expected that the survey will start in late 2025 1-2 months after the beginning of the formal Operations at the completion of construction.

# Change Record

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# Contents

# Criteria to start the Legacy Survey of Space and Time

## 1 Introduction

Rubin Observatory will be completed in 2025, perhaps as early as September. In practice this means the Operations team (see Blum, RDO-018) will assume responsibility of the Observatory and regular operations: running the facility on Cerro Pachón each night, transferring data over the long haul network to the USDF, processing and arching the data, etc.

Depending on the reliability of the overall system at the time of handover, it may be necessary to improve processes or sub-system reliability in advance of formally beginning the execution of the the 10 year Legacy Survey of Space and Time. The survey strategy and it's associated cadence in the 10 year period (allowing for modest assumed degredation in year 1) are detailed by the SCOC (The Rubin Observatory Survey Cadence Optimization Committee, PSTN-056).

In this technote, we define the criteria that the Operations team, in consultation with operations partners, the Rubin Managment Board, funding agencies, and the science advisory committee, will use to guide the decision to begin the LSST.

The LSST will begin after the handover to Operations. Currently this is forecast for the end of FY25. Formal transition of construction to staff into Operations from SLAC commissioning and AURA (into NOIRLab) will be on October 1, 2025. All construction staff can currently charge aligned activities to operations as appropriate. See section 4 below for the current schedule.

## 2 System Performance

Handover means that the system will have passed NSF and DOE close out review. The as delivered system will be capable of delivering images that satisfy the science requirements as defined in SRD (Ivezić & The LSST Science Collaboration (LPM-17)). Following the final phase of commissioning which will include science validation (SV) observations, the state of the system will be assessed and the readiness of teh system and team to begin the survey will be made.

Rubin has developed a high level metric to summarize the system performance with respect to survey efficiency. We need to ensure both that the system is producing science capable images and data products and that the observing is efficient. If the site and system are producing appropriate image quality and the system and team are acquiring data efficiently coming out of SV, we can confidently start the LSST. In Figure 1, we show the system contribution to image quality (and atmospheric contribution) versus the dimensionless survey efficiecy or “speed,” fE.

**The effective survey speed:**

**normalized etendue: fE = fS * fA * fO * "ops. efficiency"**

fS: **sensitivity factor**: defined for fiducial observing conditions and based on the knowledge of throughput (optics) and sensor properties (QE, read-out noise); all factors normalized by their nominal (design) values

fA: **the FOV area factor**: the total effective area of all live science pixels.

fO: **observing efficiency factor**: ability to schedule available obs. time

"**ops. efficiency**": the total data taking time normalized by the nominal observing time (which takes into account weather and system downtime)

FIGURE 1: Dimensionless survey efficiency factor, fE. Only ops efficiency is not known precisely at this time by data or design. The ComCam run will allow a specific determination of fE as we roll into LSSTCam commissioning. fE will be fully updated by as built system performance and ops. efficiency by the end of science validation.

All f factors are dimensionless and normalized by the corresponding SRD design values. They can be “traded against each other” as “time”. For example, deterioration in the mirror reflectivity can be easily translated to factor fS, and traded against time (e.g. time lost to recoating, the system “efficiency”), or against loss of sensor area (fA). The key point is that it is possible to define a simple measurable quantity (fE) that is an excellent numerical approximation for “LSST science goals”. Thus, we can think of the effective speed of executing the LSST (in units of the nominal speed) in terms of recognizable elements: fE ”eff area” * “eff FOV” * “cadence” * “downtime”

In Figure 2, we show the current state of our understanding of the image quality and survey speed.

There are three regions in the diagram. Clearly we want to be in the green shaded region and to the lower right in the space. The current understanding og the system as verified through subsystem verification or from the design and median seeing from the free atmoshere (0.7”) suggests we are in good shape. Experience with ComCam in late 2024 suggests we should be

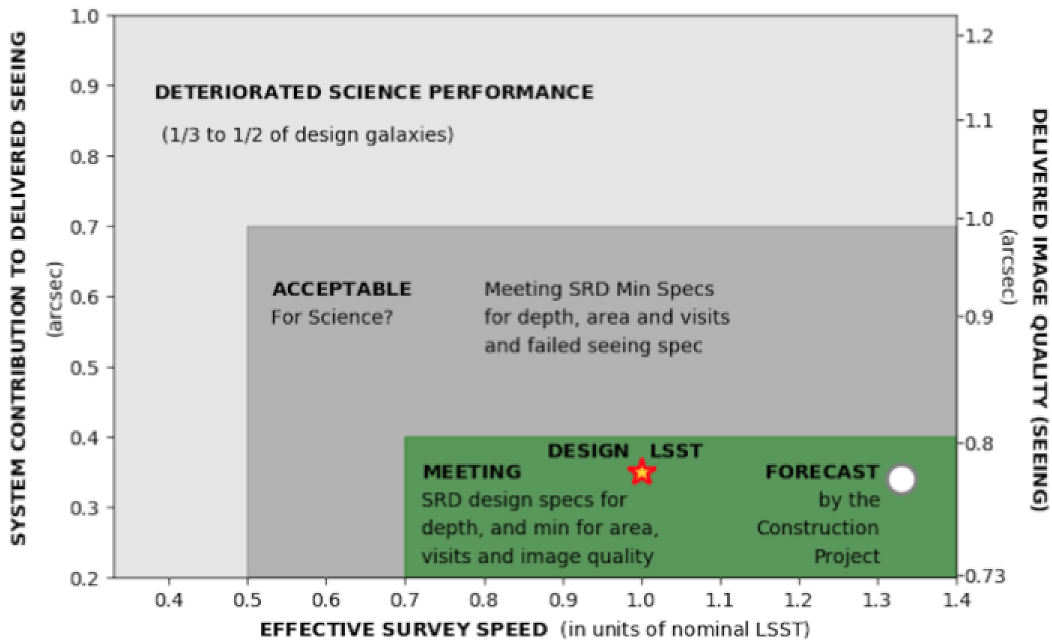


FIGURE 2: Image quality versus effective survey speed, fE. The system contribution to the image quality is shown on the left verical axis and the delivered image quality including the atmosphere (added in quadrature) is on the right. The LSST design is accomplished with nominal speed 1.0 and system IQ of 0.35″ in this diagram. Based on known subsystem performance and design, the current forecast shows the LSST will be accomplished with significant margin. Any final margin will be used to reassess the survey strategy given by The Rubin Observatory Survey Cadence Optimization Committee (PSTN-056).

able to reach high ops efficiency. This will be quantifieed in the upcoming LSSTCam commissioing period.

## 3 Criteria to begin the LSST

Armed with an understand of the system performance as outlined above and the Operations team readiness, we will use a set of objective criteria to gate the start of the LSST. These criteria will be concise and easily understandable so that the community of scientists and stakeholders counting on Rubin and the survey will have confidence the Observatory is on track.

The criteria we will use that are listed below are only to start the survey. There may be key processes within the overall system, including data management and processing that require further work after handover (beyong the construction project requirements), but unless they

Table 1: Survey Start Criteria

| Criterium | Description | Status |
|---|---|---|
| LSSTCam Maintenance | Before the completion of SV, it is understood whether or not off TMA Camera maintenance will be needed within the first year of Operations. | TBC |
| SRD | All science requirements that can be verified with SV data are verified or expected to be verified within 3 months of completion of SV. | TBC |
| IQ | Image quality contribution of system is better than 0.7". | TBC, preliminary result ComCam <0.4" |
| Speed | Survey speed as measured on SV is > 0.5. | TBC, ComCam promising |
| Improve performance | Both IQ and speed are understood with clear paths to improvement (as needed) that can be done in parallel with on going observing. | TBC |
| Dome | The dome environment is under control at night. | TBC |
| Cadence | The first six months of survey schedule includes details of the system as currently performing. | in progress |
| Fit | Team is rested and fit. | TBC |
| Early Science | DP2 observations are completed as planned (Guy et al., RTN-011). | TBC |

would prevent delaying the syrvey start, they are not discussed or enumerated here.

The Operations team discussed an initial set of criteria with the Science Advisory Committee and community at the 2024 Rubin Community Workshop. The current criteria have been eveolved since that meeting and are shown in the table below.

These criteria are not comprehensive with respect to LSST success. They are intended only to guide the confident commencement of the survey. We empahsize that the initial boundary condition is a successful completion of the construction project. This means the construction completeness reviews have been successfully completed and NSF and DOE have accepted the system as the one they intended to build.

With this in mind, the most important criterion is that the system can efficiently take data. Figure 2 shows where efficiency will be key in making progress on the survey. Beginning the scheduled observations no sooner that the system can run at 50% effective speed and with image quality (system contribution) below 0.7″ is accpetable as long as a clear path to improved performance exists. We assume the path to improvment will arrive at nominal effectiveness (1.0, 0.35″) within 6 months of the start of survey. Indeed, the ComCam capaign in Q1 FY24 showed the system contribution to image quality is likely as good 0.4″ already without full control over the in–dome environment (See On behalf of Rubin Observatory Project, SITCOMTN-149, section 2.2).

The choice of when to begin the survey based on the effective survey speed (2) is subjective. We choose 50% as the point where accummlating survey data while working on peformance improvement is most prductive for the use of nighttime hours. This is with the proviso that clear paths to performance improvement are well understood.

In order that the data taken are of the highest quality possible in this context, the dome environment should be controllable to the extent dome seeing is significantly impacting the delivered IQ. The survey schedule should be updated with the current performance for the first six month period.

Finally, the community should have a significant data set to analyize while year one data are being obtained. So, the DP2 data taking should be complete and moving toward release.

## 4 Schedule

As of March 2025, the LSSTCam is being installed on the telescope. By the first half of April, it should be pumped down and cold with intitial functional checks complete. It is expected LSSTCam and the Rubin Observatory will go on sky for the first time in mid April 2025. Figure 3 shows the current milestones for the Project and Operations.

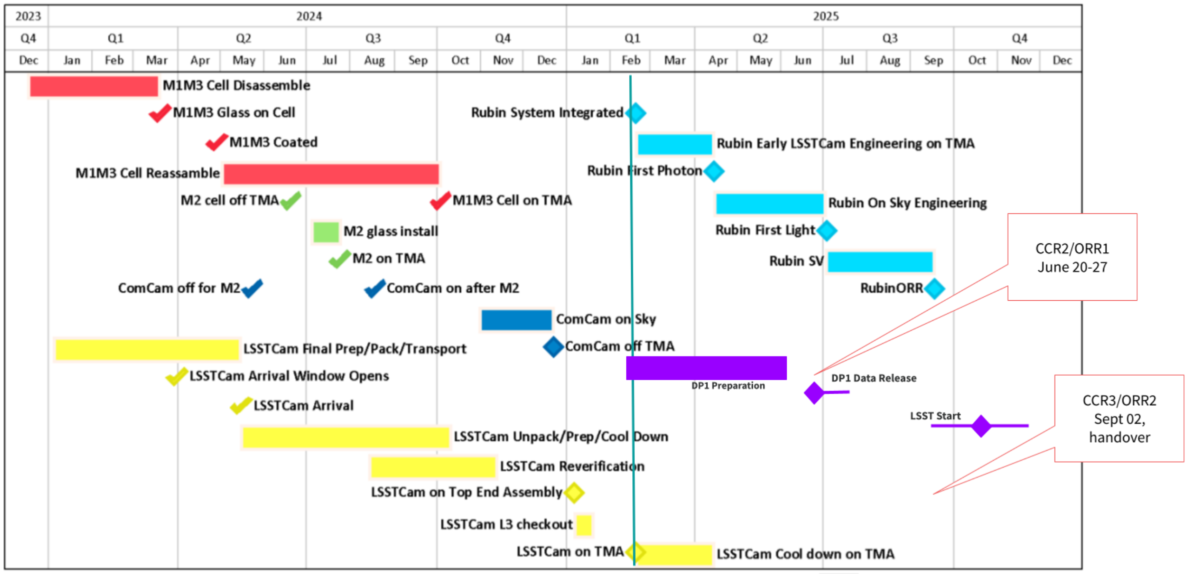


FIGURE 3: Rubin Observatory Schedule as of late February, 2025. The forecast puts the system on sky by mid April. Planning for success, the handover to Operations is planned for early September and the start of the survey by November. Formal completeness reviews including operations readiness are shown in the Figure and described in Figure 4.

The Project will complete with several reviews as described in Figure 4. The first of these, Construction Completeness Review (CCR) 1, was held in October, 2024. The main review, for substaintial completion and validation of system and science requirements, CCR2, is programed for late June, 2025. Concurent to CCR2, the Operations team will go through the Operations Readiness Review (ORR) 1. At this review, the Operations team will demonstrate they are ready for handover. That is, to assume authority and responsibility for running Rubin Observatory as a system. At CCR3, any final punchlist items from the Project will be verified and for ORR2, teh Operations team will present the schedule for starting the LSST; i.e., the status of the ssytem with respect to the criteria enumerated in this document.

**CCR1** – *readiness* for the start of on-sky commissioning, as exemplified by substantial completion and integration of subsystems, and evidenced by direct measurement of the optical throughput of the integrated system. October 2024. **Done**.

**CCR2/ORR1** – *capability* to support LSST science goals, as exemplified by the System First Light technical milestone, and evidenced by delivered single-visit image quality (including active control of optics). **June 2025.** This is substantial completeness. This is the demonstration of Operations Readiness. Currently one joint review of closeout and readiness (one panel).

**CCR3/ORR2** – *reliability* to initiate the LSST survey, as exemplified by the Science Validation surveys, and evidenced by the readiness of Rubin Observatory Operations to accept the as-built observatory..May only include Agency, Rubin, NOIRLab, SLAC. **September 2025. This is the handover event/milestone.**

**CCR4** – *closeout* of the Construction project, as exemplified by service of scientifically validated survey-scale data products as part of the Operations Early Science Program, and evidenced by completed scope of system-level requirement verification, reporting, and final accounting. **Q2, FY26.**

FIGURE 4: Construction Completeness Reviews (CCR) and concurrent Operations Readiness Reviews. CCR1-3 and ORR1-2 are required before the handover and start of LSST. CCR4 is an administrative "review". All CCRs and ORRs are convened by NSF and DOE.

## 5 References

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**[RTN-011]**, Guy, L.P., Bechtol, K., Bellm, E., et al., 2025, Rubin Observatory Plans for an Early Science Program, URL `https://rtn-011.lsst.io/`, Vera C. Rubin Observatory Technical Note RTN-011

**[LPM-17]**, Ivezić, Ž., The LSST Science Collaboration, 2018, LSST Science Requirements Document, URL `https://ls.st/LPM-17`, Vera C. Rubin Observatory LPM-17

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**[PSTN-056]**, The Rubin Observatory Survey Cadence Optimization Committee, 2025, Sur-

vey Cadence Optimization Committee's Phase 3 Recommendations, URL https://pstn-056.lsst.io/,
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## 6 Acronyms

| Acronym | Description |
|---|---|
| AURA | Association of Universities for Research in Astronomy |
| DOE | Department of Energy |
| DP2 | Data Preview 2 |
| FOV | field of view |
| FY24 | Financial Year 24 |
| FY25 | Financial Year 25 |
| LPM | LSST Project Management (Document Handle) |
| LSST | Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope) |
| NOIRLab | NSF's National Optical-Infrared Astronomy Research Laboratory; https://noirlab.edu |
| NSF | National Science Foundation |
| OPS | Operations |
| ORR | Operations Readiness Review |
| PSTN | Project Science Technical Note |
| Q1 | Quarter one |
| RDO | Rubin Directors Office |
| RTN | Rubin Technical Note |
| SCOC | Survey Cadence Optimization Committee |
| SLAC | SLAC National Accelerator Laboratory |
| SRD | LSST Science Requirements; LPM-17 |
| SV | Science Validation |
| TBC | To Be Confirmed |
| TMA | Telescope Mount Assembly |
| USDF | United States Data Facility |