Vera C. Rubin Observatory
Data Management

Rubin Observatory Plans for an Early Science Program

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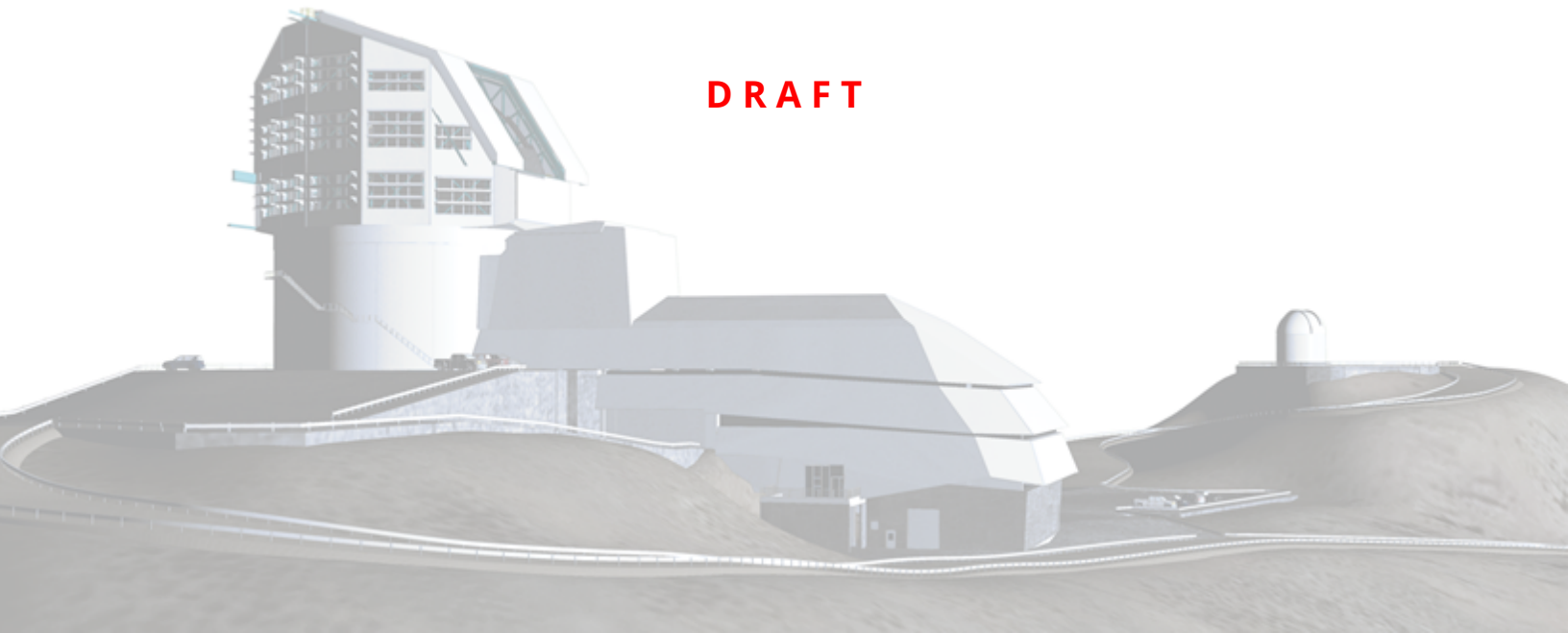

Abstract

This document outlines Rubin Observatory's plans for a dedicated *Early Science Program* to enable high-impact science prior to the first annual data release of the Legacy Survey of Space and Time (LSST). Components of the Early Science Program include releasing science-grade commissioning data products via a series of "Data Previews," ramping up of the transient alert stream during commissioning, implementing a program of incremental template generation to augment alert production in the early phases of the survey, and the first LSST Data Release, DR1, based on the first 6 months of data from the LSST. A detailed breakdown of which data products can be expected when is provided. The Rubin Operations team is working closely with the science community to optimize the Early Science Program for the time-domain and solar system science achievable in the first year of operations. This is a living document; both it and the Early Science Program will continue to evolve over the course of commissioning and pre-operations in response to the state of the as-built system and to community guidance.

Change Record

Version	Date	Description	Owner name
1	2020-10-30	First draft	Leanne Guy
2	2020-12-16	Draft 1.1	Bob Blum
3	2021-10-08	Rework structure	Leanne Guy
4	2021-10-21	Add timeline	Leanne Guy
5	2021-11-05	Edits throughout	Eric Bellm
6	2021-11-09	Global edits and consolidation	Leanne Guy
7	2022-10-14	Data Preview content, and incremental templates, revision of Early Science scenarios, address feedback from PCW 2022	Phil Marshall & Leanne Guy
8	2022-10-21	Release version 2.0	Leanne Guy
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15	2023-10-31	Updates following October schedule workshop	Leanne Guy
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17	2024-05-02	Added statement on non-sidereal tracking.	Leanne Guy
18	2024-05-03	Release version 5.1	Leanne Guy
19	2025-02-10	Major updates to the plans and data products for DP1. Revision of the Alert Production section. Release version 6.0	Leanne Guy
20	2025-02-24	Minor updates to add more information on DP1 data products. Release version 6.1	Leanne Guy
21	2025-05-30	Updates to DP1 data products, release timeline and moving object alert packet, Release version 6.2	Melissa Graham, Leanne Guy, Eric Bellm

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Rubin Observatory Plans for an Early Science Program

1 Rubin Early Science Program

Community expectations for early science with Rubin are high due to the transformative nature of the LSST data and the densely-sampled observations planned during the commissioning period. Rubin Observatory's *Early Science Program* was conceived to provide Rubin data rights holders with early access to the data products and services necessary to produce high-impact science during the period from the beginning of commissioning through the conclusion of the first year of the LSST.

1.1 Definition of Early Science

Early Science is defined as any science enabled by Rubin for its community during the period from the beginning of commissioning to the conclusion of the first year of the LSST survey. This includes the commissioning period and the first year of survey operations.

1.2 Motivation for an Early Science Program

The Early Science program is motivated by the desire to:

- enable high-impact science with Rubin Observatory data as early as possible;
- provide early access to both static-sky and time-domain science-ready data products to support the community to prepare for science with the LSST;
- enable early time-domain astronomy via early Alert Production; and
- help drive the development of Rubin operations capabilities prior to survey start and prepare the team to be operations-ready.

1.3 Elements of the Early Science Program

The Early Science Program consists of the following elements:

- A series of three **Data Previews (DP)**, DP0, DP1 and DP2, based on either simulated LSST-like data or data taken during the Rubin Observatory commissioning period.
- A world-public **stream of Alerts** from transient, variable, and moving sources that will be scaled up continuously during commissioning and the first year of the survey.
- **Template generation**, both prior to the start of regular survey operations based on data collected during the commissioning period with LSSTCam, and incrementally during the first year of regular survey operations to maximize the number of templates available for Alert Production in year 1.
- **LSST Data Release 1 (DR1)**, which will be based on the Data Release Processing (DRP) of the first six months of LSST data following the baseline survey strategy.

1.4 Transition to Operations and Early Science

The Rubin Construction project will deliver an integrated system that can capture, transfer and process science-grade data, following which, the Construction project will be declared complete and Operations will begin. The Operations team is tracking the progress of the commissioning activities (§ 2) to identify opportunities for Early Science and address the goals described in § 1.2. The data collected as part of the SV surveys in Construction will serve the dual goals of 1) ensuring that Operations is fully prepared to start the 10-year survey and 2) providing the community with an exquisite early dataset to work with while the survey begins its relentless coverage of the sky leading to DR1. All Early Science data products are opportunistic on the commissioning activities, meaning that a detailed description will only be possible once the commissioning data have been acquired and analyzed. Consequently, while the Operations team will do its best to deliver the maximum of early data, data product types and services, any statement on the contents of the Data Previews, early Alert Stream and supporting services is subject to change up until the release date.

1.5 Factors Impacting the Early Science Program

Factors affecting the schedule and contents of the Early Science program can be broadly grouped into technical considerations and policy considerations. Technical considerations include:

- The operational status of the observatory and progress of system integration and test

activities in commissioning;

- The nature and quality of the data collected during commissioning;
- The readiness of the data processing pipelines, and data distribution and access services.

Policy factors include:

- The 30-day embargo on all pixel data during commissioning;
- The 80-hour embargo on all pixel data throughout the full duration of the LSST;
- The construction security review, which must be successfully completed prior to the release of any Prompt data products;
- The Rubin First Look (RFL) media event, currently expected in June 2025 and before which no Rubin image data may be released. See RTN-083 for details.

In this document, the term "stretch goal" will be used to describe cases where any uncertainty is due to a technical or scientific consideration and "TBD" (To Be Decided) will be used when the influencing factor is of a policy nature.

2 Rubin Observatory Commissioning

2.1 Commissioning Plan and Schedule

Figure 1 shows the detailed schedule of commissioning and early science activities relative to Rubin First Light, as of May 2025. LSSTComCam First Photon was successfully achieved on 24 October 2024, followed by Rubin First Photon with LSSTCam on 15 April 2025. Rubin First Light is currently expected or 4 July 2025 (§ 7).

Figure 2 shows the high level plan for the Rubin commissioning observations. Commissioning data collection is planned to take place in phases. The On-Sky Engineering phase began with LSSTComCam and is continuing with LSSTCam. Both the System Optimization and Science Validation (SV) phases will be carried out with LSSTCam. The System Optimization phase will collect a set of observations designed to help optimize the system prior to starting the

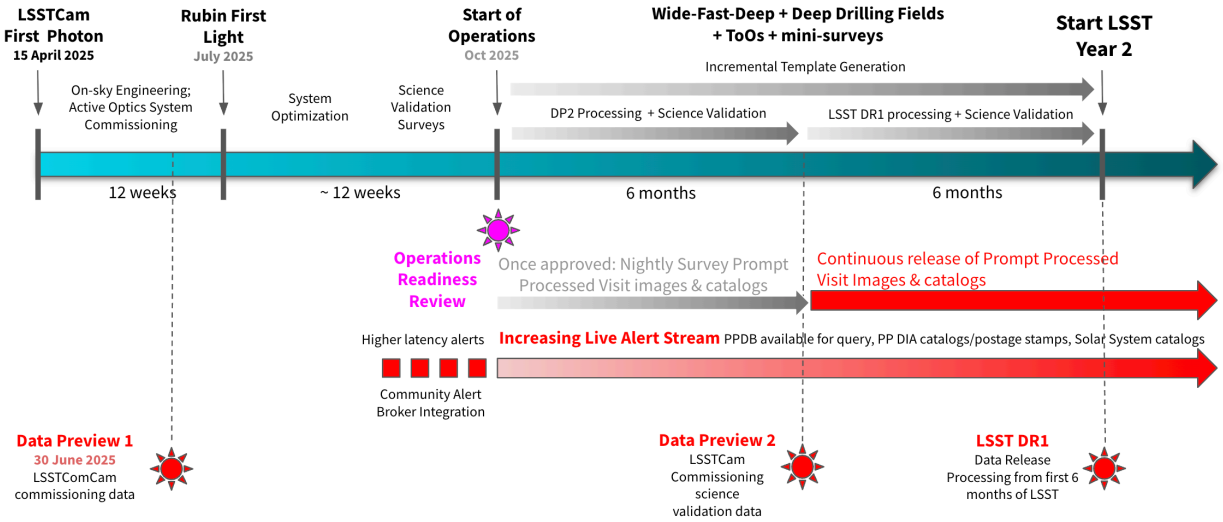


Figure 1: Detailed schedule of commissioning and early science activities relative to Rubin First Light, as of May 2025 .

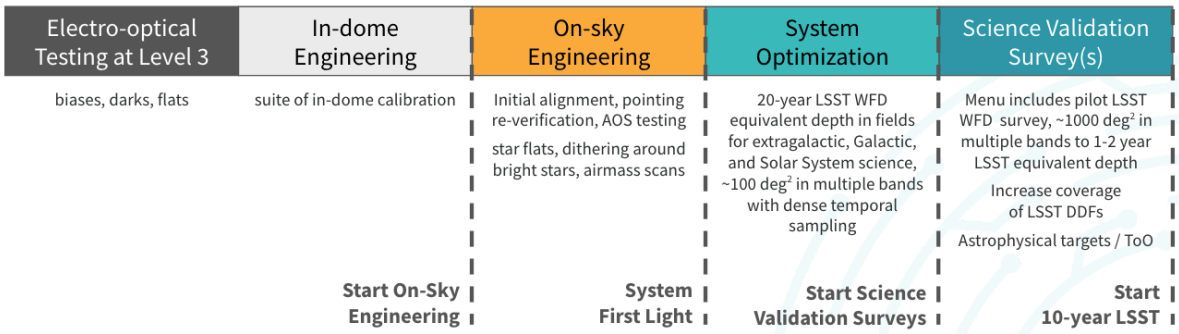


Figure 2: Outline plan for the collection of commissioning data, as of May 2025 .

Science Validation phase. During the Science Validation phase, a series of SV Surveys designed to support scientific analyses that validate the system's performance and allow Rubin to demonstrate operational readiness will be carried out. The System Optimization and SV phases contain a number of planned key components, which currently include an LSST wide-fast-deep (WFD) 1–2 year equivalent depth "pilot" survey and a 10+ year "ugrizy" depth test in three fields covering 100 sq. deg. In all phases, field selection will be carried out by the commissioning team, taking into account a wide variety of constraints as well as a "menu" of science opportunities to which the Rubin Science Community has contributed. See Section 6 of SITCOMTN-005 for the baseline design of the SV surveys. All plans for commissioning observations are subject to change based on system readiness up until the moment of execution.

The project schedule will continue to evolve as the remaining subcomponents are delivered. Construction is expected to complete and LSST data taking start before the end of 2025.

2.2 Key Commissioning Milestones

Commissioning work is being planned around three major milestones, *LSSTComCam First Photon*, *LSSTCam First Photon* and *Rubin First Light*.

ComCam First Photon: The first image of the night sky produced by photons passing through the Rubin optical system and detected by the Commissioning Camera (LSSTComCam). This milestone was achieved on 24 October 2024 .

LSSTCam First Photon: The first image of the night sky produced by photons passing through the Rubin optical system and detected by the LSST Science Camera (LSSTCam). This milestone was achieved on 15 April 2025 .

Rubin First Light: Defined as the point at which we can routinely acquire science-grade imaging across the LSSTCam full focal plane and have a well understood technical path towards meeting the Construction Completeness criteria described in SITCOMTN-061. Currently expected for 4 July 2025 .

LSSTCam First Photon occurs following the successful completion of system integration. There are no quality criteria applied to achieving the LSSTCam First Photon milestone. Rubin First Light marks the end of the on-sky engineering phase and the start of the System Optimization and Science Validation phases of commissioning. The period between LSSTComCam First Photon and Rubin First Light will focus on fine-tuning the system including optical alignment, improving the image quality, and collecting calibration data. For a detailed description of all commissioning milestones and the most current dates, see DMTN-232.

2.3 LSSTComCam Commissioning

LSSTComCam is Rubin's engineering camera that is used for testing and validating the observatory's systems and processes prior to installation of the LSST Camera. The LSSTComCam focal plane has single raft with a 3×3 mosaic of 4K×4K ITL science sensors, giving a total of 144Mpix, LSSTComCam has the same plate scale as LSSTCam (0.2 arcsec / pixel), with a field

of view of 40 × 40 arcmin. The LSSTComCam filter exchanger holds only three physical filters at a time.

The Rubin on-sky commissioning campaign using LSSTComCam began on 24 October 2024 and ended on 11 December 2024, lasting a total of 7 weeks, and included observations to support both engineering and science pipelines commissioning. This highly successful campaign included a first series of on-sky engineering tests demonstrating the end-to-end functionality of the Simonyi Survey Telescope's hardware and software systems LSSTComCam. The median delivered image quality for commanded in-focus images collected during the campaign, quantified in terms of the PSF FWHM, was ≈ 1.1 arcseconds. The best images have delivered PSF FWHM of ≈ 0.7 arcseconds. A full report on the LSSTComCam on-sky commissioning campaign is available at SITCOMTN-149.

2.4 LSSTCam Commissioning

As of May 2025, LSSTCam is installed on the Simonyi Survey Telescope and on-sky commissioning is ongoing.

3 Data Previews and Data Release 1

A series of three Data Previews (DP) and one Data Release (DR) are planned:

- Data Preview 0 (DP0): Based on simulated LSST-like data.
- Data Preview 1 (DP1): Based on a subset of early science-grade commissioning data taken with LSSTComCam during commissioning.
- Data Preview 2 (DP2): Based on a full reprocessing of all science-grade data taken with LSSTCam during commissioning.
- Data Release 1 (DR1): Based on the first six months of LSST data.

Due to the relatively short time periods available for commissioning observations (§ 1.4), the Data Previews will necessarily be limited in their area and temporal coverage relative to a full Data Release.

The data products that comprise the Data Previews and Data Releases are produced by the LSST Science Pipelines (Bosch et al., 2019, 2018). For an introduction to the LSST data products, see Graham (2022) and for a detailed description, see the LSST Data Products Definition Document (DPDD), [LSE-163]. Each Data Preview and LSST Data Release will be accompanied by its own release-specific DPDD[1], giving e.g. the database schema for the catalogs included in that dataset. Table 1 provides a summary of the expected early science data products available in DP0, DP1, DP2 and the LSST Data Release 1. All LSST data products will be subject to the embargo periods described in DMTN-199; 30 days during commissioning and 80 hours during operations for pixel data.

Rubin Early Science – Data Release Scenario

	Jun 2021	Jun 2022	Jun 2023	Jun 2025 – Jul 2025	Mar 2026 – May 2026	Sep 2026 – Jan 2027	Sep 2027 – Jan 2028	Sep 2028 – Nov 2028
	DP0.1	**DP0.2**	**DP0.3**	**DP1**	**DP2**	**DR1**	**DR2**	**DR3**
Data Product	**DC2 Simulated Sky Survey**	**Reprocessed DC2 Survey**	**Solar System PPDB Simulation**	**ComCam Data**	**LSSTCam Science Validation Data**	**LSST First 6 Months Data**	**LSST Year 1 Data**	**LSST Year 2 Data**
Raw Images	●	●	–	●	●	●	●	●
DRP Processed Visit Images and Source Catalogs	●	●	–	●	●	●	●	●
DRP Coadded Images and Object Catalogs	●	●	–	●	●	●	●	●
DRP Cell-based Coadded Images and ShearObject Catalog	–	–	–	–	●	●	●	●
DRP ForcedSource Catalogs	●	●	–	●	●	●	●	●
DRP Difference Images and DIA Catalogs	–	●	–	●	●	●	●	●
DRP SSP Catalogs	–	–	●	●	●	●	●	●

Table 1: Summary of the main data products expected in each data preview and early LSST data releases. A dark teal dot denotes confirmed data products whereas a gray dot denotes data products that currently remain a stretch goal.

The following sections outline which data products can be expected in each planned Data Preview and Data Release, and on what timescale. Table 4 in Section 7 provides a combined view of the expected data preview schedule and associated uncertainties.

3.1 Data Preview 0

Data Preview 0 (DP0) was the first of three Data Previews to be released during the period leading up to the start of Rubin Observatory Operations. Data Preview 0 contained three stages, all based on simulated LSST-like data products. DP0 was intended to serve as an early integration test of the LSST Science Pipelines and the Rubin Science Platform (RSP), and to

[1]For an example data release DPDD, see the online DP0.2 documentation `https://dp0-2.lsst.io/data-products-dp0-2/`.

enable a limited number of astronomers and students to begin early preparations for science with the LSST.

3.1.1 Data Preview 0.1

Data Preview 0.1 (DP0.1) was released to a group, approximately 300, of early adopters from the community in June 2021. It is based on simulated LSST-like images generated by the Dark Energy Science Collaboration (DESC) for their Data Challenge 2 (DC2), (LSST Dark Energy Science Collaboration (LSST DESC) et al., 2021). DP0.1 used the 300 $\deg^2$ of DC2 images that were simulated for five years of the LSST's wide-fast-deep component (WFD) using a baseline cadence, [PSTN-055]. The DESC processed the simulated DC2 images with Version 19 of the LSST Science Pipelines, producing calibrated images and catalogs. DP0.1 made the DESC's DC2 images and catalogs available to users through an early version of the Rubin Science Platform (RSP) running at the US DAC. DP0.1 has now been retired from the publicly available RSP instance.

For full details on DP0.1 including an exact description of the data products that were served, see the documentation at `https://dp0-1.lsst.io/`.

3.1.2 Data Preview 0.2

Data Preview 0.2 (DP0.2) was released to approximately 600 early adopters from the community in June 2022, exactly 1 year after DP0.1. The input simulated image dataset, DESC's "DC2," used for DP0.2 was the same as that used for DP0.1. In this case, the Rubin team itself processed the simulated DC2 images with Version 23 of the LSST Science Pipelines. DP0.2 makes the Rubin reprocessed DESC DC2 images and catalogs available to users through an early version the Rubin Science Platform (RSP) running at the US DAC.

For full details on DP0.2 including an exact description of the data products served, see the documentation at `https://dp0-2.lsst.io/` .

3.1.3 Data Preview 0.3

Delivered in June 2023, DP0.3 is the last in the DP0 series of Data Previews based on simulated LSST-like data. DP0.3 supports the Solar System Science Collaboration by hosting their simu-

Table 2: ComCam target fields and pointing centers that are to be included in the DP1 dataset. ICRS coordinates are shared in units of decimal degrees.

Field Code	Field Name	Right Ascension	Declination
		deg	*deg*
47 Tuc	47 Tuc Globular Cluster	6.02	-72.08
Rubin SV 38 7	Low Ecliptic Latitude Field	37.86	6.98
Fornax dSph	Fornax Dwarf Spheroidal Galaxy	40.00	-34.45
ECDFS	Extended Chandra Deep Field South	53.13	-28.10
EDFS	Euclid Deep Field South	59.10	-48.73
Rubin SV 95 -25	Low Galactic Latitude Field	95.00	-25.00
Seagull	Seagull Nebula Seagull	106.23	-10.51

lated 1-year and 10-year Prompt Products Database (PPDB) catalog to enable moving object analysis development in the RSP at the US DAC. DP0.3 is based on an entirely independent simulation and has no data in common with DP0.2.

For full details on DP0.3 including an exact description of the data products served, see the documentation at `https://dp0-3.lsst.io/`

3.2 Data Preview 1

Data Preview 1 (DP1) will serve data products generated from a subset of science-grade astronomically useful images taken during the ComCam on-sky commissioning campaign (§ 2.3), to enable the community to prepare to work with LSST data. The planned release date for DP1 is 30 June 2025.

Seven target fields observed as part of the ComCam on-sky observing campaign have been selected as the basis for DP1 due to their quality and scientific usefulness. These seven fields, listed in Table 2 together with their central pointing coordinates, span a range of stellar densities, have good overlap with external reference datasets, and span the breadth of the four primary LSST science themes.

Table 3 provides a summary of the band coverage for the fields used as a basis for DP1. Figure 3 shows the resulting integrated depth, expressed in terms of the flux of an unresolved source that would be measured with signal-to-noise ratio $S/N = 5$, using the r band as an example. 47 Tuc and Fornax dSph are both dense star fields, and the core of 47 Tuc is saturated

Table 3: Band coverage for seven fields observed during the ComCam on-sky observing campaign that are to be included in the DP1 dataset.

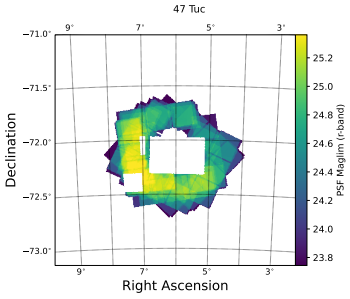
Target	u	g	r	i	z	y
47 Tuc	6	10	33	19	0	5
Rubin SV 38 7	0	44	55	57	27	0
Fornax dSph	0	5	26	13	0	0
ECDFS	53	230	257	177	177	30
EDFS ComCam	20	61	90	42	42	20
Rubin SV 95 -25	33	86	97	29	60	11
Seagull	10	37	49	3	13	0

in the LSSTComCam commissioning images. No coadds were produced for these regions during the on-sky commissioning campaign, hence the holes in the center of the figures. A typical observing epoch on a given target field consisted of 5-20 visits in each of the three loaded filters. Nearly all the visits were taken with one single 1x30 second exposure time and not 2x15 second snaps[2]. Only 1x30 second exposure images are included in DP1.

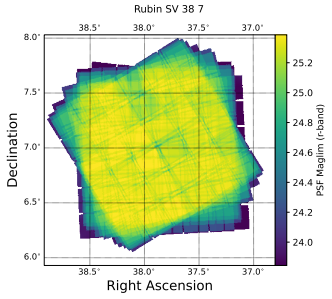
The processing and preparation of LSSTComCam data for DP1 took place during the first half of 2025. The planned data products for DP1 are presented in Table 1. DP1 is expected to include of the order of 2000 exposures. The processing of crowded fields in the centers of 47 Tuc and Fornax is on a best-effort basis. The center of 47 Tuc is saturated and so no coadd images are expected to be produced for this region. Solar System catalogs will contain observations of known objects from the MPC Orbit Catalog (MPCORB) tables as well as any new discoveries. The snapshot of the MPCORB Catalog tables included in DP1 is taken from around the time of DRP processing for DP1.

Individual exposures taken during the commissioning campaign that do not meet the quality control standard of being "science-grade, astronomically useful" images, will not be included in the DP 1 release, and consequently, the exact number of exposures and coadd depths in DP1 may be different to what was seen during the commissioning campaign. Additionally, some columns may be missing from some catalogs due to the small data sets involved in DP1. There will be no cell-based coadds in DP1, nor *ShearObject* catalog. Both of these are currently stretch goals for DP2.

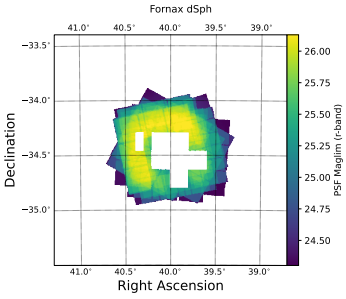
[2]At this time, studies as to whether the LSST will use a 1x30 single exposure or 2x15 snaps as the default standard visit are ongoing with LSSTCam data, and a decision will be made prior to starting the LSST.



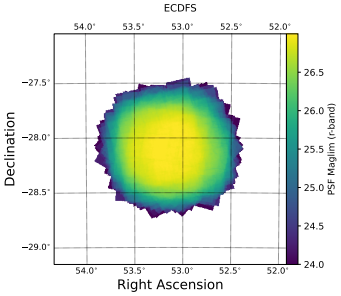
(a) 47 Tuc



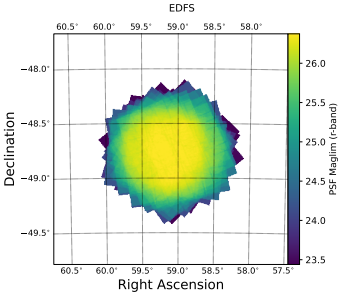
(b) Rubin SV 38 7



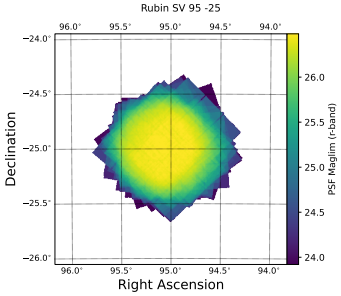
(c) Fornax dSph



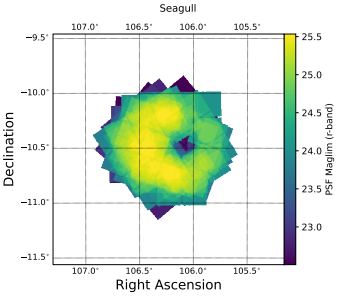
(d) ECDFS



(e) EDFS



(f) Rubin SV 95 -25



(g) Seagull

Figure 3: Cumulative imaging depth expressed in terms of the $S/N = 5$ limiting magnitude for unresolved sources for seven LSSTComCam Fields.

3.3 Data Preview 2

As the survey begins, all science-grade LSSTCam data collected during the commissioning System Optimization period and subsequent Science Validation Surveys, § 2, will be reprocessed to produce the final Data Preview, DP2. DP2 is expected to be released approximately 6 months following the start of operations. Table 1 presents a summary of the data products expected in DP2. DRP Solar System Processing (SSP) is currently a stretch goal for DP2. DRP SSP is intended to be a Rubin-only product; meaning that It does not start with the catalog from the Minor Planets Center (MPC).

3.4 Data Release 1

LSST Data Release 1 will be based on the first six months of data taken as part of the 10-year survey. Data Release Processing of this dataset is estimated to take six months, making the expected delivery date 1 year following the start of the 10-year survey. DR1 will be the first Data Release in which all data products will be provided. Table 1 presents a summary of the data products expected in DR1.

4 Alert Production in Commissioning and Early Operations

The DPDD summarizes the pipelines that will be used during Prompt Processing to produce alerts as well as other prompt data products, including Solar System Processing. Both Alert Production and Solar System Processing depend on the existence of template images. During steady-state operations, these templates will be constructed during the annual Data Releases and will be built from the best available subset of images taken. To enable alert production to proceed during commissioning and early operations, it is necessary build templates incrementally as data become available, as recommended by the study described in DMTN-107. Because we have a smaller set of input images to choose from and uncertain knowledge about future observations, incremental template generation necessarily must balance the trade-off of earlier template availability against template quality and spatial completeness. Validation will be required to determine when to build incremental templates to maximize the net throughput of Early Science. Nevertheless, our goal is to enable Alert Generation to begin over at least a subset of the survey area as soon as the data are scientifically useful.

Scientifically it is important that once a template is constructed for a given region of sky, it is used exclusively until it can be updated in the next Data Release. Repeated changes to the template make it extremely difficult to construct usable lightcurves for objects from individual difference image sources: transient objects such as supernovae will be contaminated by changing flux levels from the evolving template, and variable objects such as variable stars and AGN will require repeated corrections for different template flux levels as well.

During commissioning templates will be generated incrementally over the maximal sky area supported by the available observations. By the end of the commissioning period, coadd templates for use in difference imaging will only be available for $\approx 10\%$ of the sky. Generating templates over a wide area is not an explicit goal of commissioning; however, where possible, if commissioning observations are agnostic to pointing and filter, we would endeavour to choose a pointing and filter that maximizes building templates to enable early science.

Rubin aims to scale up alert production during commissioning with the aim of beginning early Alert Production over a progressively increasing fraction of the sky as soon as is feasible following Rubin First Light (§ 7). RTN-061 describes the criteria for sending the first Rubin alerts. Once begun, Alert Production will then proceed continuously into the full LSST survey. Alerts generated during the early science period may be produced with higher latency, and access to images and the PPDB may not be available during this phase. During commissioning and early Operations periods, alert packets for moving objects might not include the associated historical source records , and parameters such as phase curve slope (G) would be empty until sufficient detections exist to derive them. During routine LSST operations, prompt image data products, including raw images, processed single visit images (PVIs), difference images, and template images, will be made available no earlier than 80 hours following camera readout. During the first 6 months of the LSST, prompt PVIs and difference images may be released with higher latency as Rubin continues to understand data quality and scale up services.

Further details on Alert Production in Commissioning and Early Operations will be provided in the coming months.

5 Data Access Environment

The Rubin data access environment provides data rights holders with access to all Rubin data products and services. The Rubin data rights policy is described in RDO-013. Prior to the

start of survey operations, all services for data access are under active development and are provided on a shared-risk basis.

5.1 Data Access Centers

Rubin data products will be served to the community from the US Data Access Center (US DAC) hosted in the Google Cloud.[3]. A number of Rubin Independent Data Access Centers (IDAC) are also under construction to provide additional user computing resources to LSST users around the globe (RTN-003).

5.2 Rubin Science Platform

The Rubin Science Platform (RSP), described in LSE-319, is a set of integrated web-based applications, services, and tools that provides access to the Rubin data products and enables next-to-the-data analysis. The RSP comprises three different "Aspects": a *Portal* Aspect designed to provide an environment for data discovery, query, filtering, and visualization, a *Notebook* Aspect to enable next-to-the-data analysis, and an *API* Aspect for programmatic access to the Rubin data products via Virtual Observatory (VO) interfaces. The Portal and Notebook Aspects of the RSP make use of the same APIs as the API Aspect to internally access the LSST datasets.

The RSP is currently under active development and a fully functional RSP is not expected to be available until DR1. The current version of the RSP is deployed at the US DAC and will be used to host the Early Science datasets. New functionality will be deployed incrementally, as it becomes available.

RSP functionality already deployed and operational:

- TAP and Butler access to catalogs and images;
- DataLink annotations in TAP query results for access to light curves and other related information;
- ObsCore data model and ObsTAP service for image metadata and searches;
- IVOA SODA service for cutouts from individual single-epoch images and coadded image

[3] `data.lsst.cloud`

tiles[4];

- DataLink annotations to the ObsTAP service for access to the SODA service;
- Authenticated HiPS data service for seamless pan-and-zoom access to coadded data;
- IVOA-compatible SIA image service;
- Some Portal-Notebook integration features such as seeding a notebook with a query that was executed in the Portal.

RSP functionality planned to be available with DP1:

- User query history capabilities;

RSP functionality not yet available but that is expected by DP2:

- Qserv query temporary uploads;
- Context-aware documentation, e.g. pop-ups in the portal, documentation in-context such as "click on the column name and go to the page that explains it in detail;"
- Support for the ADQL spatial INTERSECTS() operation.

Most of the functionality that is expected by DP2 will be rolled out incrementally between DP1 and DP2.

RSP functionality not yet available but that is expected by DR1:

- Bulk cutout services, both for individual targets across a range of epochs, and for lists of multiple targets;
- PSF retrieval service;
- Data product recreation service;

[4]At this time, the cutout service can only process requests for one cutout at a time, meaning to create and retrieve 10 cutouts will require 10 independent synchronous calls to the cutout service. A bulk cutout service is under development and expected to be available by DR1

- Parallel computing;
- Batch processing;
- Support for collaborative work;
- WebDAV service to edit files on their RSP from their preferred device.
- Dask for parallel computing;

RSP functionality that is under consideration for post-DR1:

- Access to GPUs;
- Bringing individual resources to the RSP, e.g. additional compute paid for by individuals.

5.3 Community Brokers

Alerts are fully world-public and will be accessible via one or more of the nine Rubin-endorsed Community Brokers[5]. During the commissioning period, Rubin will work with the Community Brokers to integrate them [RTN-010]. Community access to early alerts will depend on the readiness of the Community Brokers. At this stage, we are expecting the first alerts from commissioning to become available via Community Brokers sometime following System First Light RTN-061.

6 Science Considerations for Optimizing Early Science

It will not be possible to survey the whole sky in all filters and generate templates by the end of the commissioning period. A strategy for template generation in the early phases of the survey, which will require balancing a tradeoff between various factors such as smaller area with multiple filters vs a single filter over a large area, must be devised.

There is no non-sidereal observing in the Rubin baseline survey plan and consequently there will be no non-sidereal tracking available during the early science era.

[5] See https://www.lsst.org/scientists/alert-brokers

Different science drivers naturally lead to different prioritization strategies, e.g., Milky Way science would prefer templates that cover the Galactic Plane, time domain science would prefer templates in multiple bands rather than a single band for a larger area. Supernova, transient and variable science strongly advocate for templates for all bands in the Deep Drilling Fields to be prioritized. Rubin Operations will work closely with the science community to develop a science-driven approach to template generation in the early phases of the survey that will benefit the maximum number of science cases.

6.1 Time Domain

The Transients and Variable Stars Science Collaboration (TVSSC) reviewed the opportunities for Early Science for non time-critical and time-critical science cases in (Hambleton et al., 2020) and (Street et al., 2020) respectively. In both cases, they recommend the prioritization of template acquisition in multiple bands as the preferred strategy rather than single-band coverage over a larger area of sky.

6.2 Solar System

The Solar System Science Collaboration (SSSC) reviewed opportunities for Early Science in (Schwamb et al., 2021) for several high impact solar system science opportunities that would be enabled by accelerated template generation and alert production in year 1. They find that template generation options that maximize the sky coverage in year 1 where LSST Solar System Processing can run daily are strongly preferred, even if the templates result in noisier image subtraction compared to later years.

6.3 Static Science

Datasets for static science will flow from the SV Surveys carried out during commissioning and released as Data Preview 2 (DP2). The commissioning team are planning to acquire on-sky observations that would enable science validation studies for the four LSST science drivers. Guidance is being sought from the community to enhance opportunities for science validation and early science based on commissioning data. Rubin Obs SIT-Com collected "Commissioning Notes" from the community in 2020–2021 that are being considered as part of the planning

for the on-sky observing strategy during commissioning. [6]

6.4 Target of Opportunity

Rubin Observatory will be prepared to take advantage of Targets of Opportunities (TOO) in the first year of operations (and hopefully SIT-Com). [RTN-008] describes potential data processing scenarios for TOO observations in the early operations era.

7 Roadmap and Timeline

Table 4 shows the Operations timeline and provides nominal date ranges for the various elements of the Early Science Program. The date ranges are derived from the Rubin "Celebratory Milestones", which are published monthly on the Rubin Project website[7]. For completed milestones the delivered date is given. Milestone dates are given as min – max ranges to indicate the associated uncertainty. Typically the near date corresponds to the current Project forecast, plus any additional operational uncertainty. The late date corresponds approximately to the current Project late date plus any additional operational uncertainty. The shaded region contains roughly 80% of the probability, while the lefthand edge of the shaded range indicates the earliest date the milestone could be reached. The darker regions give a very rough indication of the +/-1 sigma error bars. Over the course of the commissioning period, we expect these data ranges to shrink as our understanding of the remaining schedule uncertainty improves. However, there is still the possibility of the assumptions underlying these distributions being wrong; this is just our best estimate at the current time.

The next key milestone in the Early Science Program is the release of DP1 on 30 June 2025. The start of Rubin Operations is currently expected to be sometime from 1 October 2025. The timing of the Commissioning observations and their release to the community can only be projected to within a few months at the time of writing.

Table 4 will continue to be refined and updated in future version of this document as the Early Science Program progresses.

[6] See https://community.lsst.org/t/community-input-to-the-on-sky-observing-strategy-during-commissioning/4406

[7] ls.st/dates

Rubin Operations Survey and Data Release Timeline

Nominal LSST Start Date: October 2025

Event	Date Range
Data Preview 0.1/2/3 (DP0)	Delivered Jun 2023
Data Preview 1 (DP1)	30 Jun 2025
Rubin First Light (RFL)	Jul 2025
Rubin First Alerts (RFA)	Jul 2025 – Sep 2025
Start of Operations (OPS)	Oct 2025
Start of LSST (SVY)	Oct 2025 – Nov 2025
Start Regular Alert Production (RAP)	Oct 2025 – Dec 2025
Data Preview 2 (DP2)	Mar 2026 – May 2026
Data Release 1 (DR1)	Oct 2026 – Feb 2027
Data Release 2 (DR2)	Oct 2027 – Feb 2028
Data Release 3 (DR3)	Oct 2028 – Dec 2028

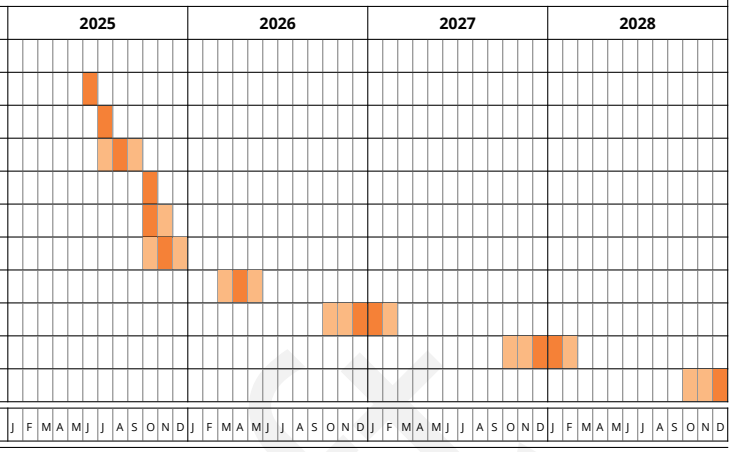


Table 4: Rubin Operations Key Milestones for Early Science

8 Community

Rubin Observatory will work closely with the Survey Cadence Optimization Committee (SCOC) and Community on the detailed design of the Early Science Program.

8.1 Survey Cadence Optimization Committee

The Rubin Survey Cadence Optimization Committee (SCOC)[8] is an advisory committee to the Rubin Observatory Operations Director consisting of 10 members drawn almost entirely from the science community. Convened in 2020, the SCOC will be a standing committee throughout the lifetime of Rubin Observatory operations and will be involved in all aspects of the development of the Early Science Program.

The SCOC will work with the Rubin Operations team and the Community to establish the best strategy for Early Science, including making specific recommendations in terms of, for example, the prioritization of sky coverage, filters, and other specific choices. Recommendations will take into account the plans for commissioning and the realized performance of the telescope and software, and should align as closely as possible with those of the main survey and ultimate long-term science goals. Optimizing the LSST Year 1 observing schedule for early science may mean that the time sampling looks somewhat different to that in subsequent

[8] See `https://www.lsst.org/content/charge-survey-cadence-optimization-committee-scoc`

years.

The SCOC has published its Phase 1, 2 and 3 survey cadence recommendations in PSTN-053, PSTN-055 and PSTN-056 respectively. The SCOC will solicit input from the community on the specific observing strategy in year 1 to optimize early science. Several science collaborations have already been proactive in providing input, both the community forum and as research notes ((Schwamb et al., 2021), (Hambleton et al., 2020), (Street et al., 2020)).

8.2 Community Forum

The Rubin Observatory Community Platform has a dedicated category for Early Science[9], where community members are encouraged to open discussions on the topic of early science. Community feedback on the Early Science data products is welcomed and will help the Rubin to improve its data products and services.

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B Acronyms

Acronym	Description
ADQL	Astronomical Data Query Language (IVOA standard)
AGN	Active Galactic Nuclei
API	Application Programming Interface
DAC	Data Access Center
DC2	Data Challenge 2 (DESC)
DESC	Dark Energy Science Collaboration

DM	Data Management
DMTN	DM Technical Note
DP0	Data Preview 0
DP1	Data Preview 1
DP2	Data Preview 2
DPDD	Data Product Definition Document
DR	Data Release
DR1	Data Release 1
DRP	Data Release Production
FWHM	Full Width at Half-Maximum
IDAC	Independent Data Access Center
ITL	Imaging Technology Laboratory (UA)
IVOA	International Virtual-Observatory Alliance
LSE	LSST Systems Engineering (Document Handle)
LSST	Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope)
MAF	Metrics Analysis Framework
MPC	Minor Planet Center
MPCORB	Minor Planet Center Orbit database
ObsCore	Observation Data Model Core Components (IVOA standard)
ObsTAP	Observation (metadata) Table Access Protocol (part of IVOA ObsCore standard)
PCW	Project Community Workshop
PPDB	Prompt Products DataBase
PSF	Point Spread Function
PSTN	Project Science Technical Note
RDO	Rubin Directors Office
RSP	Rubin Science Platform
RTN	Rubin Technical Note
SCOC	Survey Cadence Optimization Committee
SIA	Simple Image Access (IVOA standard)
SIT	System Integration, Test
SODA	Server-side Operations for Data Access (IVOA standard)
SSP	Solar System Processing

SV	Science Validation
TAP	Table Access Protocol (IVOA standard)
TBD	To Be Defined (Determined)
TOO	Target of Opportunity
US	United States
VO	Virtual Observatory
WFD	Wide Fast Deep