Vera C. Rubin Observatory
Data Management

Rubin Observatory Plans for an Early Science Program

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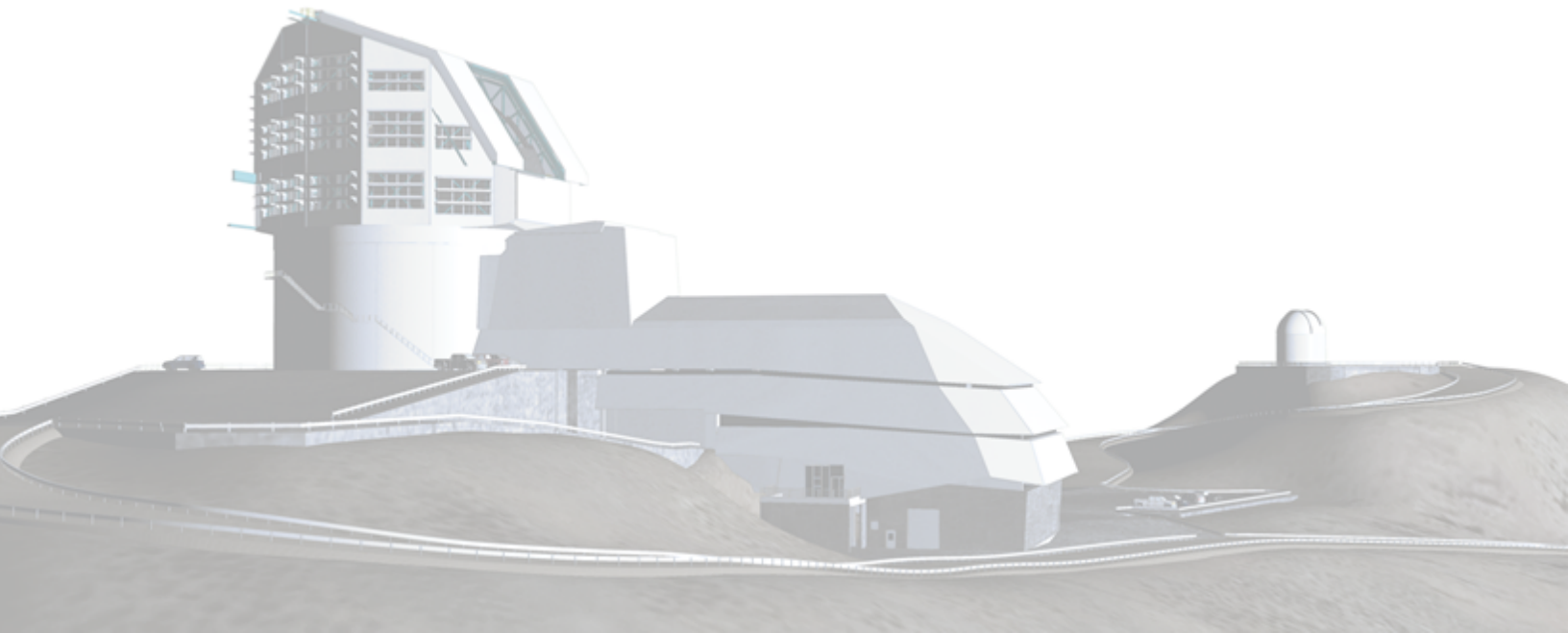

Abstract

Rubin Observatory is committed to enabling high-impact science prior to the first annual data release of the Legacy Survey of Space and Time (LSST). In this document we provide the plans for a dedicated Early Science Program designed to realize that goal. Those plans include the release to the community of Rubin commissioning data products in the form of two Data Previews, the ramping up of the transient Alert stream, and the first LSST data release, DR1, based on the first 6 months of the LSST survey. We give an overview of which data products can be expected in each of these releases and present plans to implement incremental template generation to augment alert production in the early phases of the survey. The Rubin Operations team will work 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.

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Rubin Observatory Plans for an Early Science Program

1 Summary

Rubin Observatory is putting in place a dedicated *Early Science Program* to ensure high-impact science prior to the release of the first year of Legacy Survey of Space and Time (LSST) data. The Rubin Operations team is carrying out a series of "Data Previews," in which LSST precursor data products are prepared, released to the LSST data rights community, and supported. The goals of the Data Previews are to 1) enable the Operations teams to develop operational capability prior to the start of the LSST, and 2) support the members of the LSST science community as they develops their LSST analyses. The first Data Preview, DP0, has already been released: it contains Rubin-processed image and catalog data products derived from simulated LSST images that were generated by the LSST Dark Energy Science Collaboration as the DC2 Virtual Sky Survey (LSST Dark Energy Science Collaboration (LSST DESC) et al., 2021). Subsequent Data Previews DP1 and DP2 will contain LSST-like data products generated from processing the commissioning data taken with ComCam and LSST Cam, respectively. The data taken during the first 6 months of the LSST survey will be processed and released as Data Release 1. DP1, DP2, and DR1 will all include data products for both static-sky science and time-domain science.

Time-domain astronomy is a key component of LSST's four science pillars and is enabled by alerts on LSST detections of transient, variable, and/or moving objects. Alerts are the only data product that will be immediately available (within 60 seconds of image readout) and publicly shareable, i.e. not subject to a proprietary period (Jurić et al., LSE-163), (Blum & the Rubin Operations Team, RDO-013). The worldwide community is actively preparing to process the LSST alert stream and use it to generate groundbreaking scientific results. Additionally, for many science goals, time-sensitive follow-up observations after discovery are crucial to take full advantage of the Rubin data.

A key component of the Early Science Program is the capability to build *incremental* templates from on-sky imaging as it becomes available during commissioning and the early phases of the survey. Such templates will be built periodically as images accumulate to allow for partial alert generation over an incomplete survey footprint. Where possible, templates will be built from all available commissioning data before the start of year one and used to generate alerts during year one. How extensive these templates are at the start of full survey operations will

be influenced by the overall success of commissioning. During year 1, templates will be built progressively from data obtained during year one (e.g., on a monthly timescale), and used to generate alerts during year one, either instead of, or in addition to using commissioning data to build templates.

2 Introduction

This note describes the plan for ensuring the Rubin community will have the data products and services necessary to produce high-impact early science during time between commissioning through, and including, the first data release, Data Release 1 (DR1). Community expectations for early science are high due to the transformative nature of the Rubin data and the densely-sampled observations planned in commissioning and science validation.

2.1 Definition of Early Science

Early Science (ES) is defined as any science enabled by Rubin for its community through and including the first data release, Data Release 1 (DR1). The Early Science Program has been conceived with the goal of providing science-ready data products to the Rubin community during the time between commissioning and the first LSST Data Release, DR1.

2.2 Elements of the Early Science Program

The Early Science Program consists of the following elements:

- A series of "Data Previews" based on reprocessed data taken during the Rubin Observatory commissioning period. The first, Data Preview 1 (DP1), will be based on ComCam data and the second, Data Preview (DP2), based on LSSTCam data.
- Template generation prior to the start of regular survey operations based on data collected during the commissioning period with the LSST Camera (LSSTCam) to maximize the number of templates available for Alert Production at the start of the 10-year survey.
- Incremental generation of templates during the first year of survey operations once sufficient images passing quality cuts have been acquired. These templates will then be used during year 1 to generate alerts, thus steadily increasing the number of Alerts generated over the course of year 1.

Rubin pre-operations is working with the construction project to provide early access to static-sky data products via Data Previews. The first of these, Data Preview 0 (DP0), was released to a group of early adopters from the community in June 2022 and is based on the DESC DC2

simulated dataset, (LSST Dark Energy Science Collaboration (LSST DESC) et al., 2021). Subsequent Data Previews, DP1 and DP2 will be based on the data acquired during commissioning from ComCam and LSSTCam Science Validation Surveys (SV Surveys) respectively, together with any additional science-quality data taken throughout the full commissioning period.

A key component of the Early Science Program is the generation of templates from both the commissioning data and data collected during the first year of the survey. In full survey operations, template images for difference image analysis and alert generation are constructed as part of the annual DRP. In order to support alert generation in year 1, Rubin will generate templates from all science-grade data taken during commissioning to provide an initial template library at the start of the 10-year survey, and the incrementally generate templates during year 1 using the best images available and covering as much sky in as many filters as possible. Details of the current strategy for alert generation with incremental templates are given in § 5.

2.3 Early Science scenarios

Recent planning on the construction project has led to a reduced amount of on-sky time in commissioning, including a reduction in the time dedicated to final science validation of the as-built system compared to earlier draft plans. The total amount science validation time currently planned during commissioning is 8 weeks. As Rubin construction moves through the challenging phase of System Integration, Test and Commissioning (SIT-Com), on–sky time could be further reduced.

The Operations team is tracking the progress of the commissioning activities as they relate to Early Science opportunities to ensure that the community has timely access to science-ready data products while the survey begins its relentless coverage of the sky leading to DR1.

We broadly envisage two possible scenarios emerging from the commissioning phase of the construction project:

- **Scenario A**: The full commissioning plan comprising system optimization and science validation is successfully executed as planned. The Operations team then carries out an Operations Rehearsal and Operations Readiness Review (ORR) to effectively conduct a ”full dress rehearsal” of science operations and demonstrate the readiness of the Op-

erations team to execute the 10-year survey. Data collected during commissioning and the SV Surveys is reprocessed to produce DP2, which will be released 6 months following the completion of the SV Surveys, see § 5.

- **Scenario B**: On-sky time in commissioning is reduced as the construction work draws to an end, resulting in the SV surveys not being completed prior to the end of the construction phase. The Operations team would spend up to 3 months prior to commencing the 10-year LSST survey carrying out any remaining SV Survey observations and releasing DP2 with the same data products as planned in Scenario A.

  As per Scenario A, data collected during commissioning and the SV Surveys is reprocessed to produce DP2 and an Operations Readiness Review carried out to demonstrate readiness to execute the 10-year survey.

A key point to note is that the contents of DP2 will be the same irrespective of which scenario materializes. Only the timing of the release of DP2 and the start of the 10-year survey are different between the two scenarios. In both scenarios it is assumed that the Rubin Construction project delivers an integrated system that can capture, transfer and process science-grade data at the time Operations begins. Both scenarios will include alert generation of some type, with the major distinction being the relative availability of templates in time, sky position, and filter.

These two scenarios presented are current as of October 2022, but since this document is "living," we expect the plans to mature as we approach full survey operations and the commissioning program emerges and is executed. At some future point, a single option will be adopted and executed, and at that time, the details will be more fully specified.

3 Roadmap and Timeline

The timeline shown in Table 3 below provides a list of key dates related to the Early Science program. It will be updated with more dates related to the development of the Early Science Program as they are defined.

The date ranges in the Table are derived from the "Celebratory Milestones" list published at monthly intervals on the Rubin Project website;[1] shown here are the milestones as of October

[1] https://www.lsst.org/about/project-status

Rubin Operations Top Milestones

• **Mar 2024 - Jul 2024**	Complete Delivery of Data Preview One (DP1) (L1-RO-0060)	(= Optical testing on TMA complete + 6 months)
• **Jul 2024 - Mar 2025**	LSST Survey Start (L1-RO-0110)	(= LSSTCam SV Surveys Complete + 1 months)
• **Jan 2025 - Aug 2025**	Complete Delivery of Data Preview Two (DP2) (L1-RO-0070)	(= LSSTCam SV Surveys Complete + 6 months)
• **Oct 2025 - May 2026**	Complete Delivery of Data Release One (DR1) (L1-RO-0120)	(= LSST Survey Start + 12 months)
• **Oct 2026 - May 2027**	Complete Delivery of Data Release Two (DR2) (L1-RO-0130)	(= LSST Survey Start + 24 months)

TABLE 1: Top milestones for the Early Science program, as of October 2022.

2022, which use Project controls data from August 2022.

Milestone dates are given as min-max ranges to indicate their 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: this late date cannot be surpassed without the Project re-baselining its schedule.

The late dates for the DP2 and DR1 data release milestones allow for the possibility that the Project completes within its late date, but in doing so reduces the amount of on-sky LSST Cam commissioning time. *In this eventuality, the operations team would spend up to 3 months at the start of the full/survey operations phase completing any remaining Science Validation Survey observations, such that DP2 could be realized as planned.* The LSST survey will start shortly after the completion of the SV surveys.

As can be seen in the table, the LSST survey is currently expected to start sometime between mid-2024 and early 2025. The timing of the Commissioning observations is somewhat less uncertain, but the timing of the release of those data to the community can only be projected to within 6 months at the time of writing (October 2022).

An intermediate (typically mid-range) date is used by the Rubin Operations teams for planning purposes. These nominal dates are illustrated in the timeline chart in Figure 1 below.

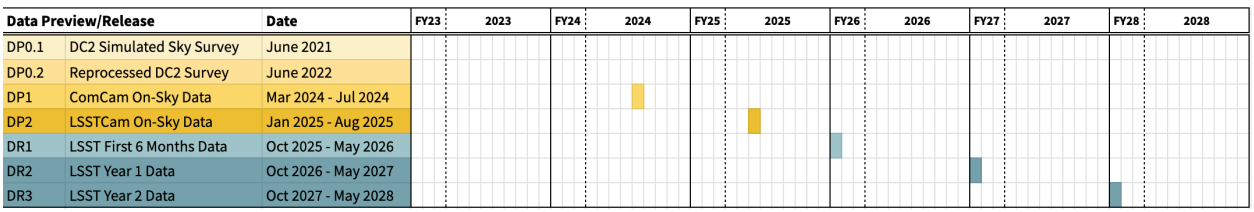

FIGURE 1: Nominal data preview and data release dates, as of October 2022.

4 Science Drivers

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. 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.

4.1 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.

4.2 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.

4.3 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 2012 that are being considered as part of the planning for the on-sky observing strategy during commissioning. [2]

4.4 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.

5 Alert Production in Commissioning and Early Operations

5.1 Processing Overview

The DPDD summarizes the pipelines which will be used during Prompt Processing to produce alerts as well as other prompt data products (§7), including Solar System Processing. In brief, raw images have instrument signatures removed and are photometrically and astrometrically calibrated. When template images for the corresponding region of the sky are available, the template is subtracted from the new processed visit image and sources are detected on the image difference. Alerts are then generated for all DIASources detected at five sigma in the difference. At the end of the night, DIASources without a history of previous detection are input into Solar System Processing, which attempts to link them with other past detections and identify new Solar System objects.

Both Alert Production and Solar System Processing thus depend on the presence of template images. During steady-state operations, these templates will be constructed during the annual Data Releases and will built from the best available subset of images taken. The input images for DRP-produced templates will accordingly have very good seeing and comprehensive spatial coverage. Coadding multiple images enables artifact rejection [DMTN-080] and reduces noise. All of these template characteristics all help to ensure that image differencing is highly complete and highly pure.

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

To enable alert production to proceed during commissioning and early operations, it is necessary to accept templates of lower quality. Because we have a smaller set of input images to choose from and uncertain knowledge about future observations, on-the-fly (or incremental) template generation necessarily must balance the trade off of earlier template availibility against template quality and spatial completeness. A template constructed today will enable alerts tomorrow, but that template might produce fewer or lower-quality alerts than one constructed from more data in a week or a month's time. Substantial 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 as soon as the data are scientifically useful.

Coadding multiple images is formally required due to the noise-level requirements placed on the DM system. Additionally, the LSST survey is heavily dithered, so without coadding many images onto a common sky plane it is both difficult and inefficient to obtain image differences for a new pointing from past single images. Finally, single-image templates do not permit removal of artifacts, transients, and moving objects from the template, creating additional false positive sources in the resulting differences.

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.

5.2 Supporting Incremental Template Generation

The Rubin Construction Data Management (DM) Science team (DM-SST), carried out a study of several options for Alert Production in Year 1, reported in DMTN-107 : Options for Alert Production in LSST Operations Year 1. Representatives of the Rubin Project Science Team (PST), DM-SST and Operations reviewed the proposed DM-SST options and converged on a the following strategy for Alerts in year 1:

- Commissioning Data Templates: Build templates, where possible, from all commissioning data before the start of year one, and use them to generate alerts during year one.

- Year One Data Templates: Build templates progressively from data obtained during year one (e.g., on a monthly timescale), and use them to generate alerts during year one, either instead of, or in addition to using commissioning data to build templates.

To handle alert generation outside the template building process attached to the annual DRP, the Construction project initiated a change request to include incremental templates in the DM system workflow. This change has been accepted and is now part of the baselined DM project in constructiom. A summary of the changes is the following:

- LCR-2273: Construct Image Differencing Templates Outside DRP, new requirement 1.4.6 Template Coadds ID: DMS-REQ-0280, The DMS shall periodically create Template Images in each of the u,g,r,i,z,y passbands. Templates may be constructed as part of executing the Data Release Production payload, or by a separate execution of the Template Generation payload. Prior to their availability from Data Releases these coadds shall be created incrementally when sufficient data passing relevant quality criteria is available.
- To enable artifact rejection, templates will be built with at least three images in year one, and five in subsequent years. (Rubin OSS-REQ-0158)
- Once a template is produced for a sky position and filter it will not be replaced until the next Data Release to avoid repeated baseline changes.
- Templates are not necessarily built from the first N images that are collected.

6 Rubin Observatory Commissioning

The baseline schedule for on-sky observations with LSSTCam during commissioning includes 3 months of technical integration and testing followed by an 8-week period of sustained observing in the form of one or more Science Validation Surveys (Claver et al., SITCOMTN-005).

6.1 Commissioning observations

Figure 2 shows the high level plan for the Rubin commissioning observations, first with the 40×40 arcmin field of view Commissioning Camera "ComCam," and then with the LSST Camera. Commissioning data collection is planned to take place in phases. A period of on-sky

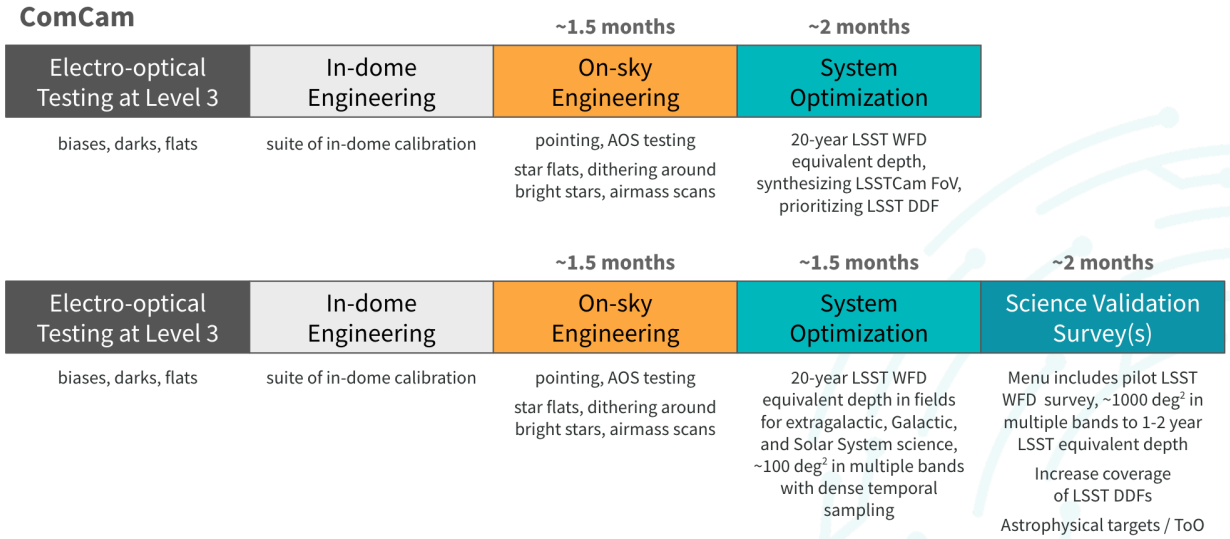

FIGURE 2: Outline plan for the collection of commissioning data, as of October 2022.

engineering time will be followed by a set of observations designed to help optimize the system, before the Science Validation Surveys are carried out. The SV surveys are designed to support scientific analyses that validate the system's performance, and allow Rubin to demonstrate operations readiness.

The figure indicates a number of key components of the system optimization and SV phases planned for each camera. These include a LSST wide-fast-deep (WFD) 1-2 year equivalent depth "pilot" survey. 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 LSST Science Community has contributed. Details of the Commissioning plans will be made available as those plans converge, in this technote and other documents as cited.

6.2 Template generation during commissioning

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. During LSSTCam commissioning we intend to incrementally generate templates over the maximal sky area supported by the available observations.

The LSST SRD places well-defined criteria on the quality of the difference image and the amount of noise that a template can contribute to a difference image. These criteria result in a minimum of three images being needed to construct a template for use in year one. The commissioning period provides an excellent opportunity to investigate how many visits in a given band are sufficient to construct a usable template. Given the desire to maximize the science harvest prior to the Data Release 1 (DR1), relaxing these criteria is an option to be explored.

6.3 Alert generation during commissioning

Due to the need to verify the instrument characteristics, template quality, and image differencing and Real/Bogus performance, real-time alerts will not be immediately available during the commissioning period. Where the accumulated ComCam data is sufficient for alert generation, we expect to provide alerts only after a delay expected to be weeks to months. The goal for these *canned* alerts is to enable alert brokers and science users to understand their characteristics and to help to validate their quality rather than to enable rapid followup and Early Science per se. Templates generated during commissioning will be used for Alert Production, with the goal of delivering real-time alert distribution to community brokers by the time of the Science Validation Surveys at the end of LSSTCam commissioning.

6.4 Data Previews based on commissioning data

Data acquired during the Science Validation Surveys is expected to be of science-quality and will be released to the Rubin data rights community via two Data Previews, Data Preview 1 (DP1) for data from the commissioning camera (ComCam) and Data Preview 2 (DP2) for data from the LSST science camera (LSSTCam) and all previous commissioning data. Data Previews will be produced using the DRP pipeline and will include data products for both static sky science and time domain science.

7 Early Science Data Products

All Rubin Observatory LSST data products are produced by the LSST Science Pipelines Bosch et al. (2019, 2018). For an introduction to the Rubin data products, see Graham (2022). Here we provide a summary of the data products that are expected to be made available as part of the Early Science Program.

Each pre-operations data preview and survey data release will be accompanied by its own release-specific DPDD, giving e.g. the database schema for the catalogs included in that dataset. For an example data release DPDD, see the online DP0.2 documentation.[3]

The Rubin data rights policy is described in Blum & the Rubin Operations Team (RDO-013).

7.1 Prompt data products

Data products for transients, variable, and moving objects will be primarily produced by the Prompt Processing pipelines, which will perform reduction, calibration, difference image analysis (DIA), source detection and measurement, and alert distribution within 60 seconds of image readout. They include images, catalogs and alerts.

During routine LSST operations, prompt image data products will be made available 80 hours following camera readout. They include raw images, processed single visit images, difference images, and template images. Prompt image products are proprietary, except for the alert postage stamps distributed in the alert stream and recorded in the alert database. The image differencing source (`DIASource`), forced photometry (`DIAForcedSource`), and object (`DIAObject` and `SSObject`) catalog data products are all public and will be available after 24 hours. Rubin Data Rights holders can access both prompt image and catalog data products via the Rubin Science Platform (§ 7.3) and query using VO interfaces. Alert are triggered by sources detected with SNR>5 via difference image analysis (DIA) and transmitted to community alert brokers for the list of selected brokers. Alert packets transmitted to these brokers are world-public. Similarly, daily Solar System Processing identifies new Solar System Objects from difference image sources and reports those publicly to the Minor Planet Center.

7.2 Data Release data products

Static science datasets for Early Science will flow from the Science Validation Surveys in commissioning. Images and catalogs from the DRP of the commissioning data will be made available to data rights holders in the form of Data Previews via the access mechanisms described in § 7.3. Due to the relatively short time periods available for commissioning observations (§ 2.3), these Data Previews will necessarily be limited in their area and temporal coverage relative to full Data Releases, however all Data Preview data products will be in the same sci-

[3] `https://dp0-2.lsst.io/data-products-dp0-2/`

TABLE 2: Summary of data products expected in each data preview and early survey data release, as of October 2022.

Rubin Early Data Release Scenario	Jun 2021	Jun 2022	Mar 2024 - Jul 2024	Jan 2025 - Aug 2025	Oct 2025 - May 2026
	DP0.1	DP0.2	DP1	DP2	DR1
Data Product	DC2 Simulated Sky Survey	Reprocessed DC2 Survey	ComCam On-Sky Data	LSSTCam On-Sky Data	LSST First 6 Months Data
Raw images	☑	☑	☑	☑	☑
DRP Processed Visit Images and Visit Catalogs	☑	☑	☑	☑	☑
DRP Coadded Images	☑	☑	☑	☑	☑
DRP Object and ForcedSource Catalogs	☑	☑	☑	☑	☑
DRP Difference Images and DIASources	☐	☑	☑	☑	☑
DRP ForcedSource Catalogs including DIA outputs	☐	☑	☑	☑	☑
PP Processed Visit Images	☐	☐	☑	☑	☑
PP Difference Images	☐	☐	☑	☑	☑
PP Catalogs (DIASources, DIAObjects, DIAForcedSources)	☐	☐	☑	☑	☑
PP Alerts (Canned)	☐	☐	☑	☑	☑
PP Alerts (Live, Brokered)	☐	☐	☐	☑	☑
PP SSP Catalogs	☐	☐	☑	☑	☑
DRP SSP Catalogs	☐	☐	☐	☐	☑

ence data model format as for future Data Releases.

7.3 Access to Early Science data products

Alerts will be accessible by the community via one or more of the nine Rubin-endorsed Community Brokers[4]. The Rubin Data Rights community will access the Rubin data products via the Rubin Science Platform, (Jurić et al., LSE-319).

7.4 Summary of expected Early Science data products

The tables in this section outline which data products can be expected in each Early Science data preview and data release, and when.

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

TABLE 3: Summary of data products expected in DP1, as of October 2022.

DP1	**ComCam On-Sky Data**		
Serving data products generated by both the Rubin Construction Project Commissioning Team and the Rubin Operations team, from astronomically-useful images taken with ComCam, to a larger number of delegates from the LSST Science Community, at the IDF.			
Milestone ID:		L1-RO-0060	
Data Products Available Prior to the Data Release:		Prompt products will be generated, but they will all be retained for internal use only prior to the data release except for Solar System products sent to the MPC.	
Data Release:		Mar 2024 - Jul 2024	
Data Product		**Date**	**Notes**
DRP Processed Visit Images and Visit Catalogs	☑	Data Release	
DRP Coadded Images	☑	Data Release	
DRP Object and ForcedSource Catalogs	☑	Data Release	
DRP Difference Images and DIASources	☑	Data Release	
DRP ForcedSource Catalogs including DIA outputs	☑	Data Release	
PP Processed Visit Images	☑	Data Release	*The ComCam images will be the first Rubin data that PP will be run on, to start commissioning image differencing and incremental template building.*
PP Difference Images	☑	Data Release	*Difference imaging will be somewhat limited, since the image template sky coverage will be sparse.*
PP Catalogs (DIASources, DIAObjects, DIAForcedSources)	☑	Data Release	*PPDB made available as part of the Data Release.*
PP Alerts (Canned)	☑	Data Release	*SAC-selected Rubin Broker teams will be given earlier access to the canned Alerts, for development purposes. The Alert DB will made available with the DR.*
PP Alerts (Live, Brokered)	☐		
PP SSP Catalogs	☑	Prompt Production / Data Release	*Measurements of known SSObjects in DP1 difference images sent to the MPC to commission that connection. Searches for new SSObjects performed if appropriately-cadenced data is present in commissioning. SSP Catalogs then available in PPDB in the DR.*
DRP SSP Catalogs	☐		

TABLE 4: Summary of data products expected in DP2, as of October 2022.

DP2	**LSSTCam On-Sky Data**		
Serving data produced by both the Rubin Construction Project and Rubin operations re-processing, to the whole LSST Science Community, from the US DAC at SLAC.			
Milestone ID:		L1-RO-0070	
Data Products Available Prior to the Data Release:		Prompt products will be generated, alerts streamed, and the PPDB made available, but images will be retained for internal use only prior to the data release.	
Data Release:		Jan 2025 - Aug 2025	
Data Product		**Date**	**Notes**
DRP Processed Visit Images and Visit Catalogs	☑	Data Release	
DRP Coadded Images	☑	Data Release	
DRP Object and ForcedSource Catalogs	☑	Data Release	
DRP Difference Images and DIASources	☑	Data Release	
DRP ForcedSource Catalogs including DIA outputs	☑	Data Release	
PP Processed Visit Images	☑	Data Release	*Prompt image release embargoed during commissioning.*
PP Difference Images	☑	Data Release	*Prompt image release embargoed during commissioning.*
PP Catalogs (DIASources, DIAObjects, DIAForcedSources)	☑	Prompt Production	*PPDB available for query prior to the DR.*
PP Alerts (Canned)	☑	Prompt Production	*AlertDB available as a prompt product, as in survey operations.*
PP Alerts (Live, Brokered)	☑	Prompt Production	*Aiming for "near-live" brokered Alert stream by the end of LSSTCam SV.*
PP SSP Catalogs	☑	Prompt Production	*Measurements of known SSObjects sent to the MPC whenever difference images are available.. Searches for new SSObjects performed if appropriately-cadenced data is present. SSP Catalogs then available for query in PPDB prior to the DR.*
DRP SSP Catalogs	☐		*DRP SSP may be run in order to demonstrate operations readiness, but the products will likely not be released.*

TABLE 5: Summary of data products expected in DR1, as of October 2022.

DR1	**LSST First 6 Months Data**		
Serving data produced by Rubin operations, from observations in the first 6 months of observations, at the US DAC at SLAC, Chilean DAC, and the IDAC network. Includes brokered alerts from templated sky regions.			
Milestone ID:		L1-RO-0120	
Data Products Available Prior to the Data Release:		Alerts with image postage stamps, plus queryable PPDB, from prompt processing. Full FPA visit images will be available 3 days after observation.	
Data Release:		Oct 2025 - May 2026	
Data Product		**Date**	**Notes**
DRP Processed Visit Images and Visit Catalogs	☑	Data Release	
DRP Coadded Images	☑	Data Release	
DRP Object and ForcedSource Catalogs	☑	Data Release	
DRP Difference Images and DIASources	☑	Data Release	
DRP ForcedSource Catalogs including DIA outputs	☑	Data Release	
PP Processed Visit Images	☑	Prompt Production	*Y1 is the first time that the processed visit images will be made available as prompt products.*
PP Difference Images	☑	Prompt Production	*Difference imaging will steadily increase as incremental template building increases the templates available.*
PP Catalogs (DIASources, DIAObjects, DIAForcedSources)	☑	Prompt Production	*PPDB available for query.*
PP Alerts (Canned)	☑	Prompt Production	*AlertDB available as a prompt product.*
PP Alerts (Live, Brokered)	☑	Real Time	*Alert latency to decrease smoothly to "live" between SV and early survey.*
PP SSP Catalogs	☑	Prompt Production	*Standard SSP Daily Data Products produced from difference images as they are available and reported to the MPC*
DRP SSP Catalogs	☑	Data Release	*DRP SSP uses only LSST data (no MPCORB info) to understand selection effects. This is only really valuable once we have a significant amount of LSST data, so DR1 at the earliest.*

8 Survey Cadence

The early science observations can be separated into two kinds: commissioning observations, and survey observations taken during the first 6 months of the LSST.

Optimizing the LSST Year 1 observing schedule to maximize early science may mean that the time sampling in the LSST survey region looks somewhat different to that in subsequent years. Likewise, the Year 1 coadd depth should, to first order, be as uniform as any other year in the LSST, but there could also be some second order effects. The Survey Cadence Optimization Committee (SCOC) will work with the Rubin Survey Scheduling Team to study the impacts of optimizing the early survey observations for early science, and also take input from the LSST science community on further, small adjustments to the early survey cadence so as to enable particular aspects of early science.

9 Community Engagement

Rubin Observatory will work closely with the community on the detailed design of the Early Science Program.

9.1 Survey Cadence Optimization Committee

The Survey Cadence Optimization Committee (SCOC) is an advisory committee to the Rubin Observatory Operations Director consisting of 10 members drawn almost entirely from the science community. The SCOC was convened in 2020 and will be a standing committee throughout the life of Rubin Observatory operations.

Early Science observations should align as closely as possible with the main survey and ultimate long-term science goals; the SCOC will be involved in all aspects of development of the Early Science Program. The SCOC will make specific recommendations for Early Science observations, based on the plans for commissioning and the realized performance of the telescope and software.

9.2 Community Forum

The Rubin Observatory Community Platform has a dedicated category for Early Science[5], where community members are encouraged to open discussions on the topic of early science.

9.3 Community Input

A process will be put in place to formally solicit input from the community. Several science collaborations have already been pro-active in providing input on considerations for template generation in year one on both the community forum and as research notes.

9.4 Community Feedback

Community feedback on the Early Science data products is welcomed and will help the Rubin to improve data products and services.

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B Acronyms

Acronym	Description
AGN	Active Galactic Nuclei

ComCam	The commissioning camera is a single-raft, 9-CCD camera that will be installed in LSST during commissioning, before the final camera is ready.
DC2	Data Challenge 2 (DESC)
DESC	Dark Energy Science Collaboration
DIA	Difference Image Analysis
DM	Data Management
DM-SST	DM System Science Team
DMS	Data Management Subsystem
DMS-REQ	Data Management System Requirements prefix
DMTN	DM Technical Note
DP0	Data Preview 0
DP1	Data Preview 1
DP2	Data Preview 2
DPDD	Data Product Definition Document
DR1	Data Release 1
DRP	Data Release Production
ES	Early Science
LCR	LSST Change Request
LSE	LSST Systems Engineering (Document Handle)
LSST	Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope)
MAF	Metrics Analysis Framework
ORR	Operations Readiness Review
OSS	Observatory System Specifications; LSE-30
PCW	Project Community Workshop
PST	Project Science Team
RDO	Rubin Directors Office
RTN	Rubin Technical Note
SCOC	Survey Cadence Optimization Committee
SIT	System Integration, Test
SNR	Signal to Noise Ratio
SRD	LSST Science Requirements; LPM-17
SST	Subsystem Science Team
SV	Science Validation

TOO	Target of Opportunity
VO	Virtual Observatory
WFD	Wide Fast Deep
arcmin	arcminute minute of arc (unit of angle)