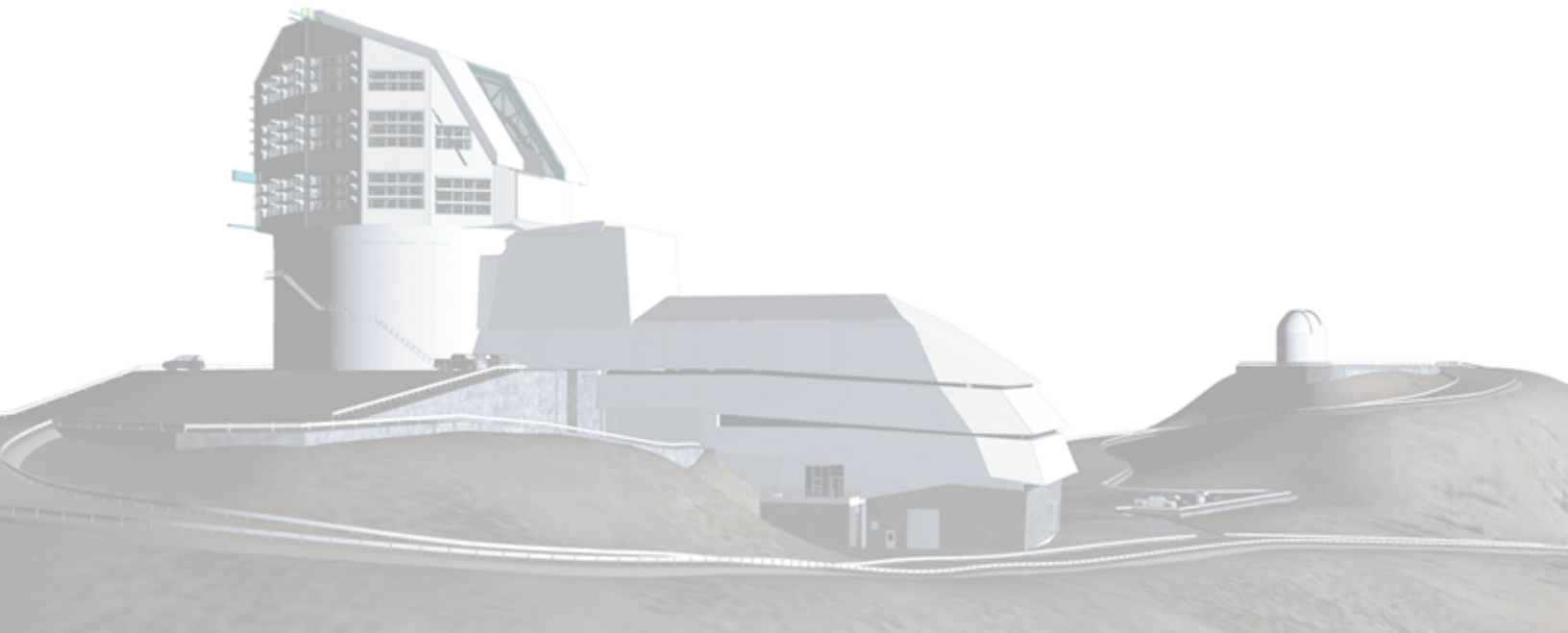

Vera C. Rubin Observatory
Data Management

Plans for Early Science

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RTN-011

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Abstract

Science during the first year of Rubin Observatory / LSST operations is a high priority. Alerts to of transient, variable, and/or moving objects. 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. The worldwide community is actively preparing to process the LSST alert stream and use it to generate groundbreaking scientific results. This note describes the Rubin Observatory Production plan for ensuring Early Science . It is a living document that will evolve over the course of the remainder of the construction project and up until Data Release 1 (DR1) .

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

Document source location: `https://github.com/rubin-observatory/rtn-011`

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Plans for Early Science

1 Introduction

This note describes plan for ensuring the Rubin community will have sufficient data access, data products, and data analysis tools to produce early science when the full Legacy Survey of Space and Time (LSST) begins. The start date for full survey operations is uncertain at this time, but we assume for purposes of planning that it will be no earlier than October 1, 2023.

One of the four science pillars of LSST is time-domain astronomy, which 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 (not subject to a proprietary period; LSE-163). The worldwide community has been actively preparing to process the LSST alert stream and use it to generate groundbreaking scientific results

1.1 Definition of Early Science

Early Science (ES) is any science enabled by Rubin by its community that happens before Data Release 1 (DR1) at the end of the first year of full survey operations. Expectations for early science have largely been high due to the extensive amount of on sky time planned in commissioning and science verification (SV).

1.2 Motivations for Early Science

Explain that the motivation for the Early Science programme is that in the current baseline there will be no science before Data Release 1 (DR1). This is due to the fact that templates needed for Difference Imaging are produced in Data Release Production (DRP) and Data Release 1 (DR1) is not until 1 year after the start of operations.

1.3 Early Science scenarios

Recent planning on the construction project has led to a reduced amount of on–sky time and SV time. As Rubin construction moves through the challenging phase of System Integration,

Test and Commissioning (SIT-COM), on–sky time could get squeezed more. The Operations team is thus planning for various outcomes that might require special attention to producing ES opportunities in the first part of regular operations to ensure the community has access to exciting data and data sets while the survey begins its relentless coverage of the sky before DR1.

In all cases, it is assumed Rubin Construction hands Rubin Operations a system that can capture, move, and process science quality data at the time Operations begins. Planning will then consider three high level options to ensure ES. These are initially described in this document, but the document is ”living” and we expect the plans to mature in detail over time as we approach full survey operations and the extant SIT-COM program emerges and is executed. At some point, a single option will be adopted and executed:

- *P*lan A: SV is completely successful, move quickly to the LSST and DR1,
- *P*lan B: Early Science Period (3-6 months) that is different than regular survey operations because on ? sky time in SIT-COM is reduced, leading to few science ready data before the LSST begins
- *P*lan C: further shakedown of operations procedures and data taking is required even though the initial condition above is satisfied and the Rubin System can capture and produce science quality data.

Each option (A, B, or C) will include alert processing and generation of some type. The principle aspect of this in SIT-COM and year 1 operations is incremental template generation. 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 incrementally generate templates in SIT-COM and year 1 using the best images available and covering as much sky as possible given other needs which must be addressed as well. Details of the current strategy for alert generation (prompt processing, PP) with incremental templates are given below section Section 5.

2 Timeline

This timeline provides a list of key dates related to the Early Science program.

2021-11-01: Issue first version of the Rubin Observatory Production plan for Early Science. Advertise it broadly to the Rubin science community.

2023-01-01: Commissioning Camera (ComCam) on sky

2023-07-01: LSST Science Camera (LSSTCam) on sky

2023-10-01: Start of the science verification surveys

2024-01-15: Current earliest completion date for construction

2024-XX-XX: Current forecast start date for LSST data taking

3 Science Drivers

The various different science drivers outlined in 3 naturally lead to different priorities for template generations, e.g. solar system science prefers templates to be generated in the NES and Milky Way science would to would prefer templates for the galactic plane to optimise alert production in these areas in early operations. Other science will prefer templates in a number of filters to enable .. rather that larger area.

3.1 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.

3.2 Solar System

The Solar System Science Collaboration (sssc) reviewed opportunites for Early Science in 2021. LSST is predicted to discover $\approx$ 6 million solar system planetesimals, providing in total over a billion photometric and astrometric measurements in 6 broad-band filters.

3.3 Static Science

The baseline static science data sets will flow from Science Verification surveys carried out during commissioning.

3.4 Target of Opportunity

Rubin Observatory will be prepared to take advantage of Targets of Opportunties (TOO) in the first year of operations (and hopefully SIT-COM).

4 Rubin Observatory Commissioning

4.1 Schedule

Outline the current schedule

4.2 Science-driven prioritization of sky templates

By the end of the commissioning period, coadd templates for use in difference imaging will only be available for $\approx$ 10% of the sky. This leaves open the question of how to prioritize sky areas and bandpasses to optimize the science harvest prior to Data Release 1 (DR1).

4.3 Template generation during commissioning

4.4 Template verification in commissioning

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. Science collaborations The commissioning period provides an excellent opportunity to investigate how many visits in a given bad are sufficient to construct a template that is good enough. Given the desire to maximize the science harvest prior to the Data Release 1 (DR1), relaxing these criteria might be preferable.

5 Alert Production in Year One

*D*escribe the relaxed requirements on noise contributed to a difference image by the template

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 requirment 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 Early Science Data Products

6.1 Prompt data products

Describe the alert data products

6.2 Data Release data products

Images and catalogs from the DRP of the commissioning data will be made available to data rights holders via the access mechanisms described in 6.3.

6.3 Access to Early Science data products

Describe how the Early Science data products will be accessed by the community. Describe the community brokers, the science platforms and how the Data Previews play a role in providing access to Early Science data products. Explain that the same data rights policy applies to Early Science data products. Blum & the Rubin Operations Team (RDO-013).

7 Survey Cadence

In this section we discuss the implications of any Early Science program on the baseline cadence and overall survey strategy. This section should reference the three early science scenarios presented in 1.3 and explain the implications on the survey cadence for each strategy.

8 Communication

Describe here the process by which the community will be consulted and decisions will be made about the early science programme.

Points to address:

- Use of the community platform for engaging the community to provide input,

- Process by which we officially solicit input from the community on preferences for early science, e.g number of filters, vs area vs pointings vs …. Each different science has a different preference.
- Decision making criteria
- Decision making body
- Timeline for making collecting input and making a decision

Rubin community members can open discussions on the topic of early science on the Rubin Community Forum Early Science category

Several science collaborations have already been pro-active in providing input on template generation in year one, 2021, 2020, 2020

A References

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Hambleton, K., Bianco, F., Clementini, G., et al., 2020, Research Notes of the AAS, 4, 40, URL https://doi.org/10.3847/2515-5172/ab8129, doi:10.3847/2515-5172/ab8129

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B Acronyms

Acronym	Description
B	Byte (8 bit)
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.
DM	Data Management
DM-SST	DM System Science Team
DMS	Data Management Subsystem
DMS-REQ	Data Management System Requirements prefix
DMTN	DM Technical Note
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
OSS	Observatory System Specifications; LSE-30
PP	Prompt Processing
PST	Project Science Team
RDO	Rubin Directors Office
RTN	Rubin Technical Note
SIT	System Integration, Test
SIT-COM	System Integration, Test and Commissioning
SRD	LSST Science Requirements; LPM-17
SST	Subsystem Science Team
SV	Science Validation
TOO	Target of Opportunity