

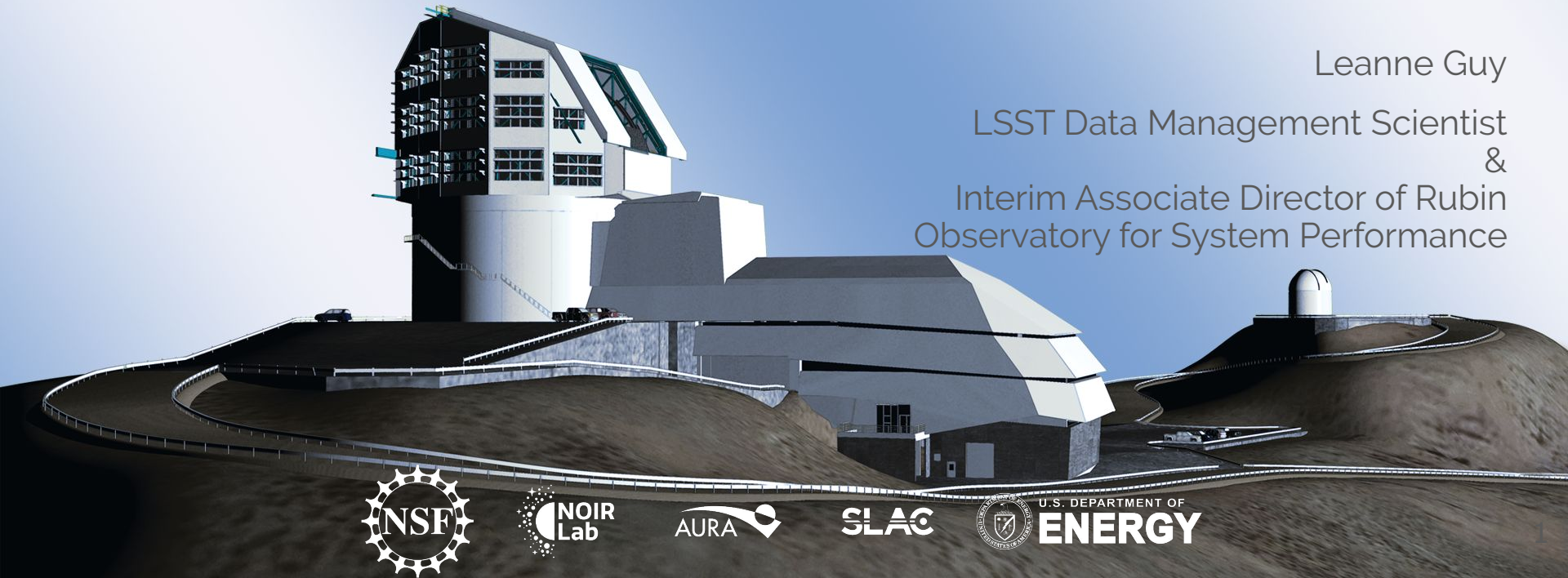
## Early Science: LSST Operations Year 1 and Alert Generation

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&  
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Observatory for System Performance



U.S. DEPARTMENT OF  
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- Early Science is any science enabled prior to the first data release, DR1.
- DR1 is scheduled for release for 12 months after the start of operations (and based on the first 6 months of data),
- Expectations of early science have been built on the basis of substantial science verification and validation surveys, and data previews coming out of commissioning (Phil Marshall's talk at this sprint, Rubin PCW2019).
- We have also informal guidance from NSF to ensure early science is evident (i.e. year 1).



## Prompt Data Products

Real Time Difference Image Analysis (DIA)

- A stream of ~10 million time-domain events per night (Alerts), transmitted to event distribution networks within 60s of camera readout.
- Images, Object and Source catalogs derived from DIA, and an orbit catalog for ~6 million Solar System bodies within 24h.
- Enables discovery and rapid follow-up of time domain events



## Data Release Data Products

Reduced single-epoch & deep co-added images, catalogs, reprocessed DIA products

- Catalogs of ~37 billion objects (20 billion galaxies, 17 billion stars), ~7 trillion sources and ~30 trillion forced source measurements.
- 11 Data Releases, produced ~annually over 10 years of operation
- Accessible via LSST Science Platform & LSST Data Access Centers.



## User Generated Data Products

User-produced derived, added-value data products

- Deep KBO/NEO, variable star classifications, shear maps, etc ...
- Enabled by services & computing resources at the LSST DACs and via the LSST Science Platform (LSP).
- 10% of LSST computing resources will be allocated for User Generated data product storage & processing.

Rubin  
Observatory



- Alerts are a product of Difference Image Analysis (DIA).
- Difference Image Analysis requires coadded transient-free template images.
- Templates are built during Data Release Production (DRP) and made available through LSST Data Releases.
- The LSST Data Release Scenario currently envisages Data Release 1 (DR1) for one year after the start of LSST operations, and to be based on the first six months of data.
- Consequently, Alert Production cannot run at full scale nor full fidelity in year 1.
- “Baseline” science thus implies from year 2.

# Planned On-Sky Observing Campaigns

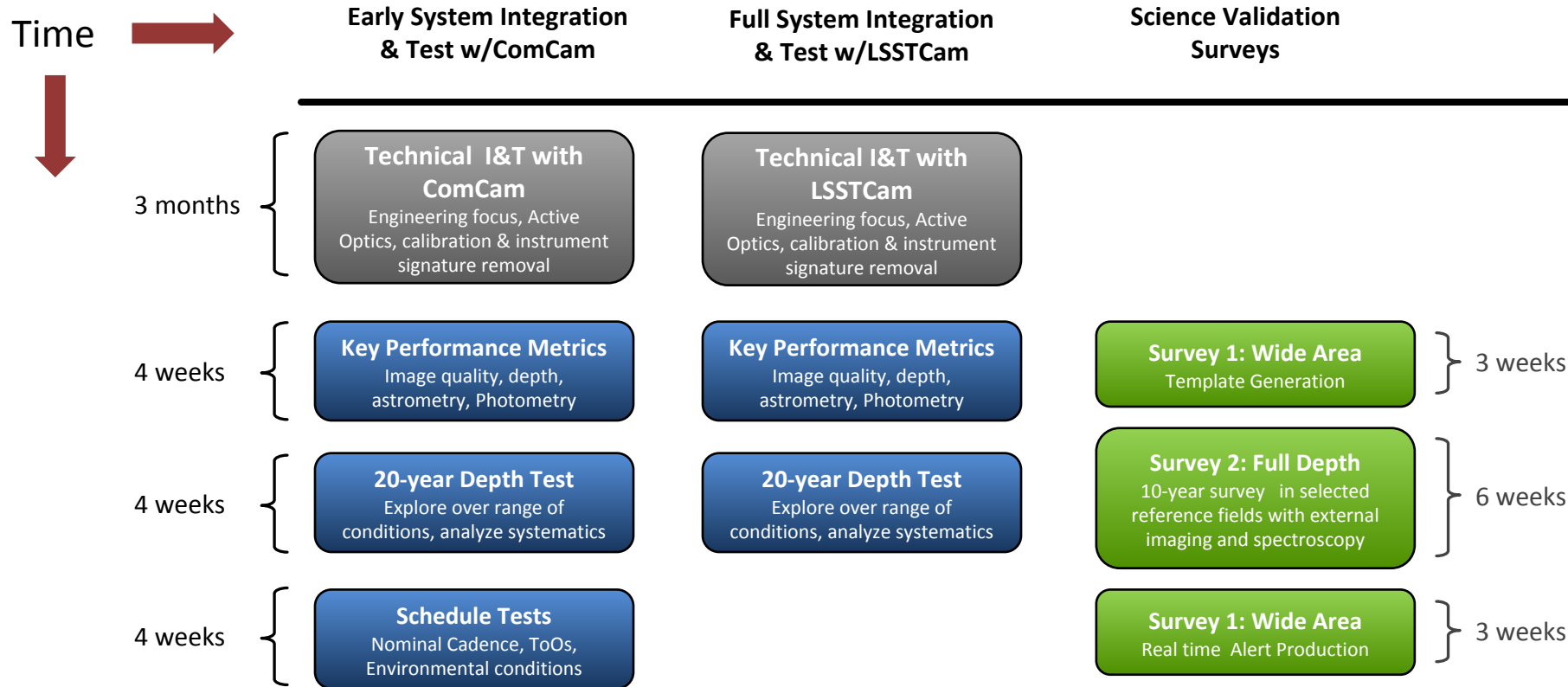


Image credit: Chuck Claver

# Planned On-Sky Observing Campaigns

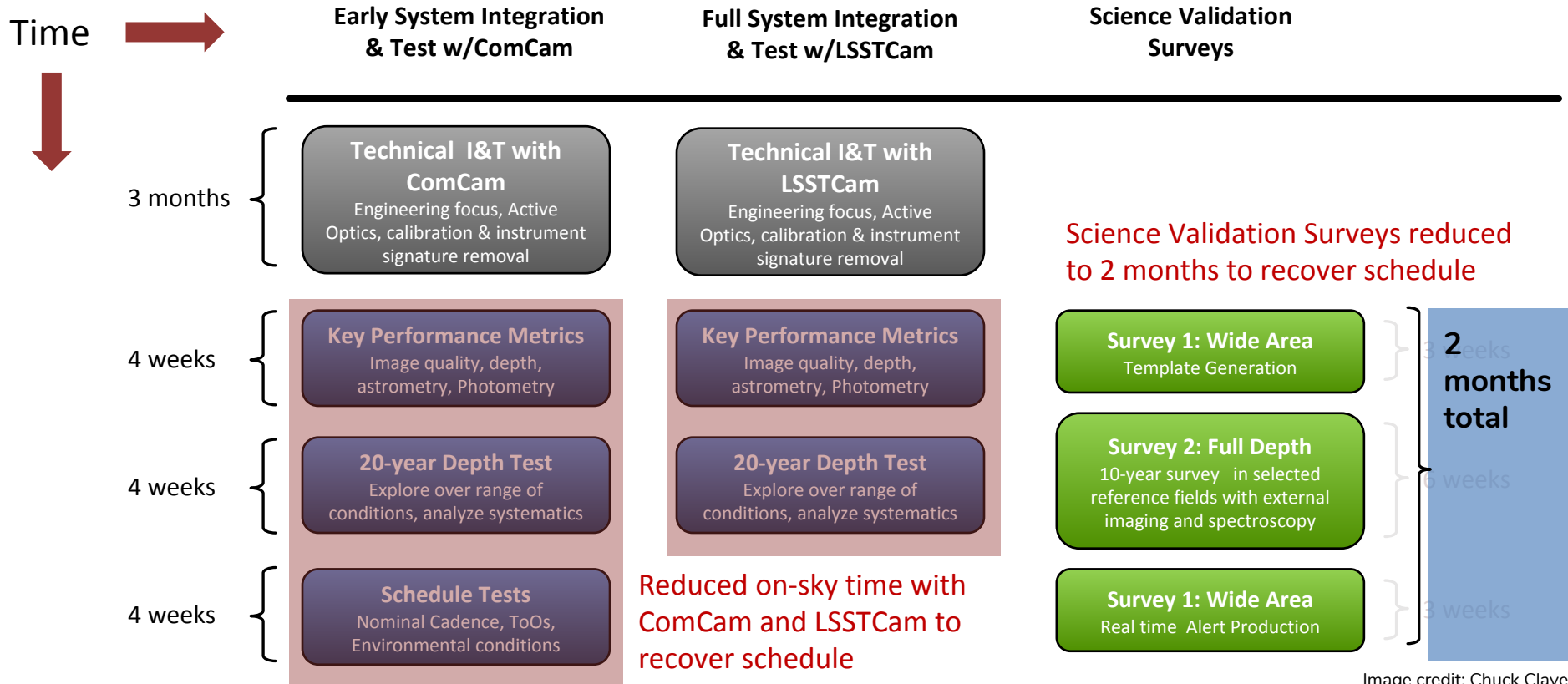


Image credit: Chuck Claver

Rubin Operations Team is developing a plan to ensure Early Science based around three possible scenarios:

1. Commissioning goes well but there is little template generation in SV. The system is “ops ready” but templates from commissioning and SV surveys do not cover the full sky nor in all filters.
2. Hugely successful commissioning and SV, with huge amounts of templates generated before year 1.
3. There is still commissioning work left to do in year 1 for full operations readiness, which would constrain any early science and also the ability to generate lots of templates.



- The DM Science team (DM-SST), recently 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 LSST-PST, DM-SST and LSST Operations Project reviewed the proposed DM-SST options at a meeting in October and converged on a proposed strategy for Alerts in year 1:
  - **Commissioning-Data Templates:** Build templates, where possible, from all commissioning data before the start of LOY1, and use them to generate alerts during year 1.
  - **Year 1-Data Templates:** Build templates progressively from data obtained during year 1 (e.g., on a monthly timescale), and use them to generate alerts during year 1, either instead of, or in addition to using commissioning data to build templates.

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DM Baseline Change!

- [LCR-2273](#): -- 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.** -- Accepted
- To enable artifact rejection and to comply with OSS-REQ-0158, templates will be built with at least three images in year 1 (five in subsequent years).
- 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.
- Requirements on the temporal range and airmass binning removed – greater flexibility in meeting other performance requirements.

- What if on-Sky commissioning activities are further reduced?
- An ~3 month “campaign for early science” is a possibility – non-survey activity could delay DR1 (which may be OK)
- What is the best use of time in this period?
  - Align ES as closely as possible with regular survey operations (don’t waste time)?
  - Time domain science enabled by incremental template generation (do SV survey 1?)
  - Provide catalogs (e.g. Magellanic Clouds, DDFs, and other calibration fields)
  - What is needed for cosmology and galaxies?
  - Peer review for one month of community proposals
- How do we develop the process?

What does incremental alert generation capability and SV/commissioning template generation imply for cadence of year 1?

- Science collaborations have started to publish research notes highlighting early science opportunities in year 1 based on detections in difference images and the requirements on templates (e.g maximize area vs noisier difference images. )
- Different cadences/filters will favour different science; need to run simulations and present the possibilities to stakeholders; choices will need to be made.
- If the year 1 cadence is different, we need to understand the impact on the 10-yr science goals of the survey.

# Opportunities for High Impact Solar System Science During Year 1 of the Legacy Survey of Space and Time (LSST)

Megan E. Schwamb <sup>1</sup>, Mario Jurić <sup>2</sup>, Bryce T. Bolin <sup>3,4</sup>, Luke Dones <sup>5</sup>, Sarah Greenstreet <sup>6,2</sup>, Henry H. Hsieh <sup>7,8</sup>,  
Laura Inno <sup>9</sup>, R. Lynne Jones <sup>10,11</sup>, Michael S. P. Kelley <sup>12</sup>, Matthew M. Knight <sup>13,14</sup>, William T. Reach <sup>15</sup>,  
Tom Seccull <sup>16</sup>, Colin Snodgrass <sup>17</sup> And David E. Trilling <sup>18</sup>






for the LSST Solar System Science Collaboration

## Impact of Rubin Observatory LSST Template Acquisition Strategies on Early Science from the Transients and Variable Stars Science Collaboration: Non-time-critical Science Cases

K. Hambleton<sup>1</sup> , F. Bianco<sup>2</sup> , G. Clementini<sup>3</sup> , M. Dall'Ora<sup>4</sup> , R. Egeland<sup>5</sup> ,  
N. Hernitschek<sup>6,7</sup> , M. B. Lund<sup>8</sup> , I. Musella<sup>9</sup> , A. Prša<sup>1</sup> , V. Ripepi<sup>10</sup> , K. G. Stassun<sup>6,7</sup> ,  
R. A. Street<sup>11</sup> , R. Szabó<sup>12,13</sup> , and

On Behalf of the Rubin Observatory Transients and Variable Stars Science Collaboration  
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[Research Notes of the AAS, Volume 4, Number 3](#)

## Impact of Rubin Observatory LSST Template Acquisition Strategies on Early Science from the Transients and Variable Stars Science Collaboration: Time-critical Science Cases

R. A. Street<sup>1</sup> , F. B. Bianco<sup>2</sup> , R. Bonito<sup>3</sup> , T. Giannini<sup>4</sup> , M. L. Graham<sup>5</sup> , R. Margutti<sup>6</sup> ,  
E. Mason<sup>7</sup> , A. Pastorello<sup>8</sup> , M. C. Stroh<sup>6</sup> , P. Szkody<sup>5</sup>  [+ Show full author list](#)  
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[Research Notes of the AAS, Volume 4, Number 3](#)

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Please take a moment to review our [community guidelines](#).

## Science-driven prioritization of sky templates during commissioning plans

■ Science observingstrategy, commissioning



This is the first time fedhere has posted – let's welcome them to our community!



**fedhere** Federica

1  Nov '19


Let's generate a science-driven optimization of the template collection and generation plan for LSST during commissioning.

2



 Reply

created

 Nov '19

last reply

 Mar 29

17

replies

543

views

13

users

4

likes

6

links



**fedhere** Federica

Nov '19

From the PST-SC chairs conversation on 11/20/2019, being clear that the templates for image differencing will only be available for a fraction of the sky (~10%?) by the end of commissioning, we should discuss what combination of sky areas and bandpasses should be prioritized and make recommendations for alert-generation in DR1. Different science drivers would lead to a different plan for template collection, e.g. trivially MW science would prefer templates in the galactic plane, EG science and cosmology outside of the plane. Please share this board with all of the SCs. At the appropriate time we will move this discussion to a more formal venue to make official recommendations.



Nov 2019

**1 / 18**

Nov 2019

Mar 29



- High impact Solar System science prefers template generation options that maximize the sky coverage.
- Time critical TVS science enhanced by templates in multiple filters, preferably r and g bands
- To address the large range of variability timescales templates generated from images collected at a range of time separations is desirable
- DESC SN and SL WGs emphasize importance of building good DDF templates in commissioning for SN science operations to begin in year 1,
- Noisier image subtraction compared to DR1 often preferred to no DIA at all  
... etc and many more



# Charge To The Survey Cadence Optimization Committee (SCOC)

– See Lynne Jones' talk at this sprint

## The Purpose of the SCOC

The SCOC is advisory to the Rubin Observatory Operations Director (currently Bob Blum). It will begin its work in 2020, and will be a standing committee throughout the life of Rubin Observatory operations.

Its tasks are as follows:

- Based on input from the OpSim team and the Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) Science Collaborations, make specific recommendations for the cadence choices for the full 10-year survey. These recommendations will include a description of the pros and cons of the various choices, and will be in the form of one or more reports which will be made public.
- Help communicate these recommendations to the science community through, for example, posts on [community.lsst.org](https://community.lsst.org) and reports to the LSST Science Collaborations.
- Based on the plans for commissioning, and the realized performance of the telescope and software, make specific recommendations for "Early Science" observations, to be carried out at the end of commissioning and the first months of Rubin Observatory operations.
- During operations, receive reports from the Survey Evaluation Working Group (SEWG), a project-internal group of scientists that will evaluate the current and expected performance of the survey and scheduler. Use this information, together with an understanding of the science outputs and changing scientific landscape of the Rubin Observatory, to make recommendations for changes in survey strategy, including Target of Opportunity observations and the use of Director's Discretionary Time.

- Reach out to all science collaborations, ensure they have had the chance to give input
- Review all community feedback on Alert Generation in year 1, understand what is possible and what the implications of the various scenarios are, and then present it to the SCOC to make the decision.
- Rubin full operations proposal now planned for Dec 2021.
- Pre-covid, and informed in part by NSF's desire to announce research opportunities, we aimed to have an initial plan for early science by end of 2020
  - Stick to this and produce a plan littered with caveats? or
  - Postpone and produce a more concrete plan for later in FY21?

# Questions

Rubin Observatory,  
Cerro Pachon  
17 February 2020



**Q: Can you touch on what the Rubin Observatory's timeline is for making a decision about what kind of template generation will be pursued/implemented in Year 1 operations?**

A: We are building a plan now to ensure successful early science with Rubin, however the specific template strategy we will adopt will not be known until we are much closer to the start of operations. The rebaseline will have an effect on commissioning and SV activities and handover to operations. The state of the system as we enter operations will affect the choice of template strategy to optimize early science.

**Q: In terms of the structure/organization of the Rubin Observatory, who takes charge of the Solar System Processing Pipelines after the full start of operations. Does that continue to be Mario's team?**

A: Solar System pipelines and data products fall into the category of “Prompt Data Products”. The Prompt and Data Release Processing algorithms, pipelines and their execution will be the responsibility of the Data Production Department (see Phil's slides). At least in the initial years of operations, the same teams as in construction will continue to be responsible for them. That may change over the course of 10 years of operations.

# Rubin Observatory

## Backup Slides



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1. Use the templates already built for science verification.	<p>During Final Science Verification, templates will be made for <math>\sim 1600</math> deg<sup>2</sup> as a part of Mini-Survey 1. (10% of WFD; LSE-79).</p> <p>Using these templates in LOY1 would enable alerts to be produced across that area, and constitute no expansion of scope.</p>
2. Build templates from all commissioning data.	<p>An additional <math>\sim 300</math> deg<sup>2</sup> from Science Validation Survey 2, and <math>\sim 100</math> deg<sup>2</sup> from the 20-Year Depth Test (Early Science Verification), plus any and all other images from the rest of Commissioning.</p> <p>Building these templates for use in LOY1 (<math>&gt;14\%</math> of WFD) would enable more alerts to be produced, and constitute only a small expansion of scope.</p>
3. Prioritize building single-filter templates during commissioning.	<p>(A) Dedicate <math>\sim 4</math> good-quality, non-consecutive nights to obtaining <math>\sim 3</math> visits/field in a single filter over a contiguous extragalactic <math>\sim 10000</math> deg<sup>2</sup> area (50% of WFD; filter r or i, TBD).</p> <p>and/or</p> <p>(B) Design a “Template-Building Observing Program” that the commissioning team can run when their activities are agnostic about filter and pointing, which could likely achieve the above.</p>

- QA activities on the incremental templates will be performed as they are generated and spread throughout year 1
- It will be more difficult to identify subtle systematic effects in the templates produced incrementally, but it may prove beneficial in early ops to be able to refine the template validation activities in time rather than performing a single concentrated validation effort as part of a DRP.
- Quality criteria are not yet defined and we expect to generate these criteria during commissioning
- Templates are not necessarily built from the first N images that are collected



# Pre-Operations Data Previews

Rubin Operations Milestones			2021				2022				2023				2024			
Date	Quarter	Milestone	FY21 DP0 at IDF				FY22 Transition to USDF				FY23 Commissioning				FY24 Year 1			
2021-03-31	FY21 - Q2	DP0.1 Early Access: Provide access to processed images and visit level catalogs from the IDF																
2021-06-30	FY21 - Q3	DP0.1 Data Release: science-ready catalogs released from the IDF																
2021-09-30	FY21 - Q4	DP0.2 Early Access: Provide access to reprocessed images and visit level catalogs from the IDF																
2022-03-31	FY22 - Q2	DP0.2 Data Release: science-ready catalogs from reprocessed DP0 images released from the IDF																
2022-10-31	FY23 - Q1	DP1 Early Access: provide access to processed images and visit level catalogs from the USDF																
2023-03-31	FY23 - Q2	DP1 Data Release: science-ready catalogs released from the USDF																
2023-06-30	FY23 - Q3	DP2 Early Access: provide access to processed images and visit level catalogs from the USDF.																
2023-12-15	FY24 - Q1	DP2 Data Release: science-ready catalogs from the final Data Preview (LSSTCam SV) released to community from the USDF.																

- Three pre-survey data releases, the “Data Previews,”
- Collaborating with the LSST DESC to use their DC2 dataset in DP0, throughout FY21, and also looking at HSC data.
- DP1 and DP2 will involve releasing and supporting commissioning data

**Previous baselined Specification:** The DMS shall periodically create Template Images in each of the u,g,r,i,z,y passbands that are constructed identically to Deep Detection Coadds, but where the contributing Calibrated Exposures are limited to a range of observing epochs `templateMaxTimespan (1year)` , the images are partitioned by airmass into multiple bins, and where the quality criteria may be different.

**New baselined Specification:** 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

**Discussion:** Image Templates are used by the Image Difference pipeline in the course of identifying transient or variable sources. The range of epochs must be limited to avoid confusing slowly moving sources (such as high proper motion stars) with genuine transients. It is anticipated that separate templates will be created in each passband for 3 separate ranges of airmass

**Discussion:** Image Templates are used by the Image Difference pipeline in the course of identifying transient or variable sources. The temporal range of epochs may be limited to avoid confusing slowly moving sources (such as high proper motion stars) with genuine transients. Incremental template building enables Alert Production when no Data Release template is yet available. It is anticipated that incremental template generation could be run nightly, but 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. To enable artifact rejection and to comply with OSS-REQ-0158, incremental templates will be built with at least three images.