LSST Project Status and Plans for Operations

Steven M. Kahn
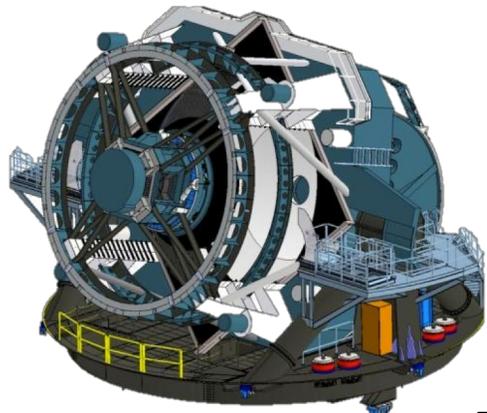**LSST Director**

Committee on Astronomy and Astrophysics
National Academy of Sciences
March 28, 2019
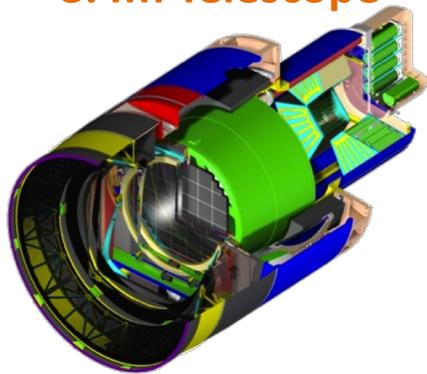
CAA Meeting – Washington, DC – March 28, 2019

LSST: An observing facility to conduct 10-year optical survey, process, archive, and serve images and data products
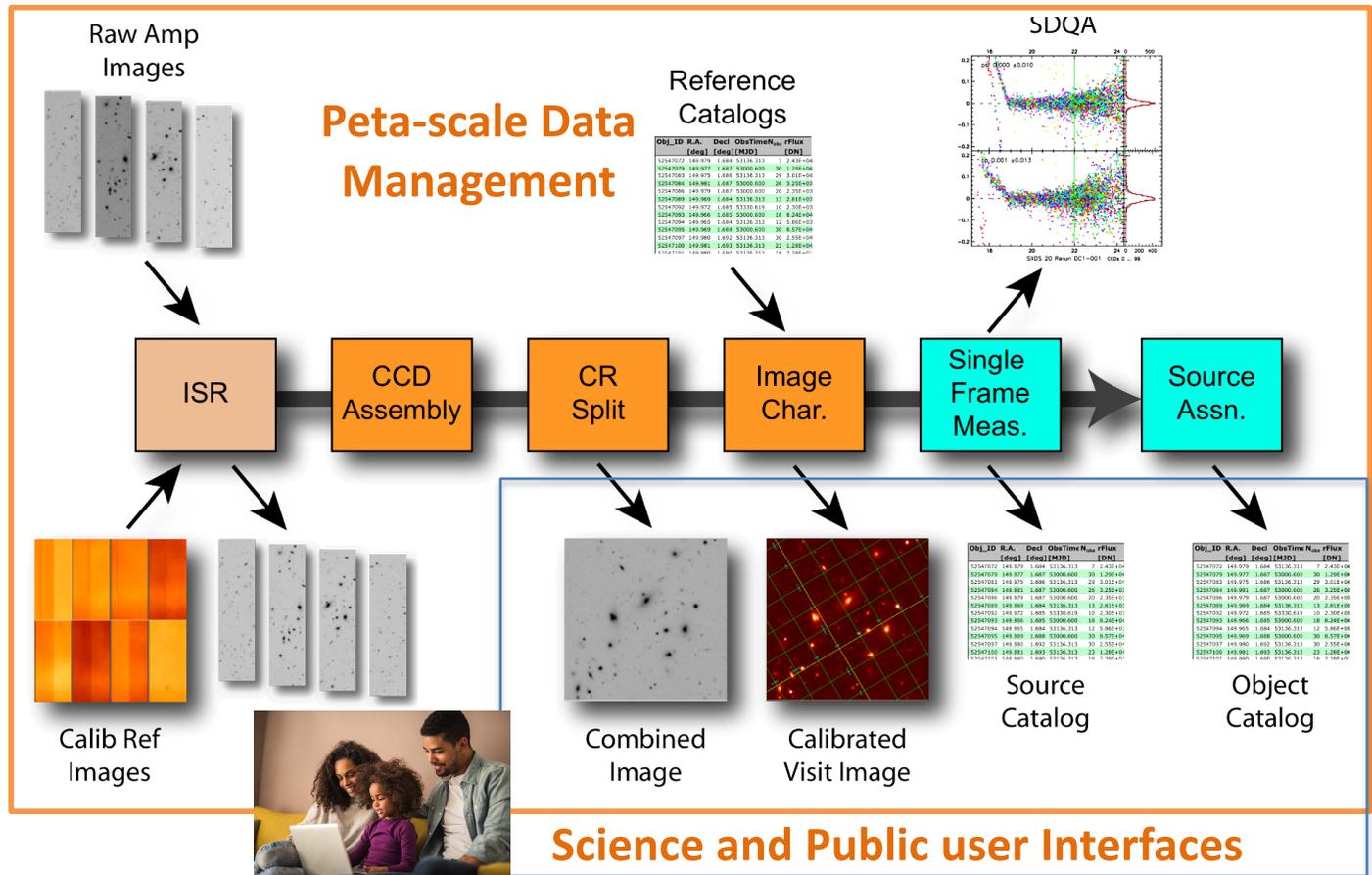
8.4m Telescope

3.2Gpix Camera

+

Peta-scale Data Management

Raw Amp Images

Reference Catalogs

SDQA

ISR → CCD Assembly → CR Split → Image Char. → Single Frame Meas. → Source Assn.

Calib Ref Images

Combined Image

Calibrated Visit Image

Source Catalog

Object Catalog

Science and Public user Interfaces

Data Products

- A stream of ~10 million time-domain events per night, detected and transmitted to event distribution networks within 60 seconds of observation.
- A catalog of orbits for ~6 million bodies in the Solar System.

Prompt

- A catalog of ~37 billion objects (20B galaxies, 17B stars), ~7 trillion observations ("sources"), and ~30 trillion measurements ("forced sources"), produced annually, accessible through online databases.
- Deep co-added images.

Data Releases

The production of data products will be transparent: All software is developed open-source and will be available to the community.
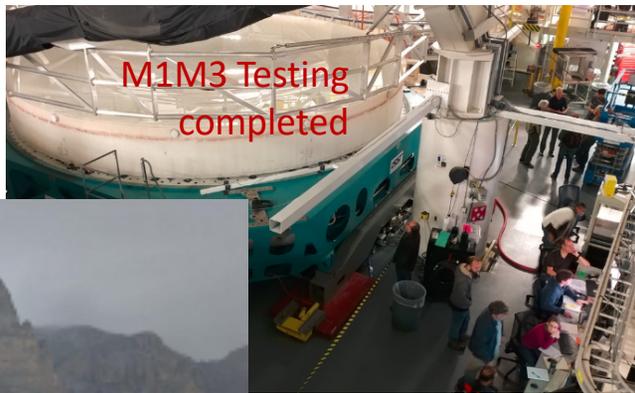
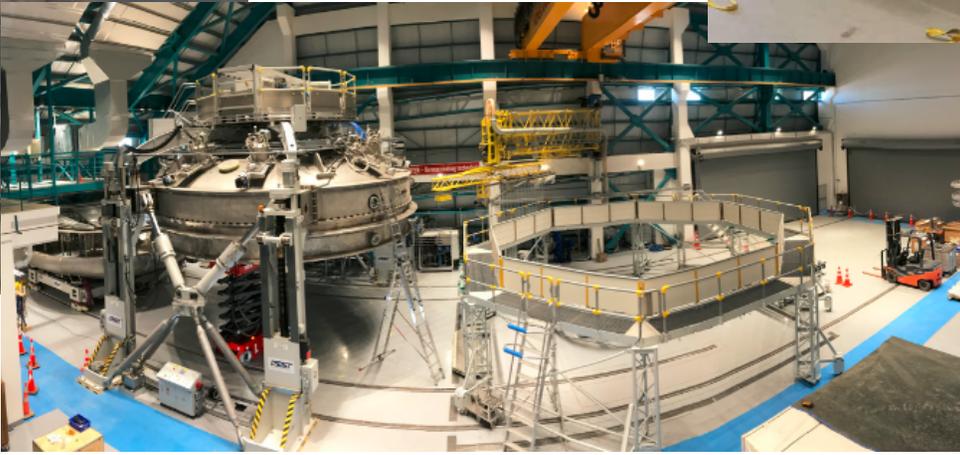# Telescope Progress Summary

M1M3 Cell back at CAID

M1M3 Testing completed

M2 Cart with cell and Surrogate mirror

M1M3 glass trucked to Houston

AuxTel under computer control
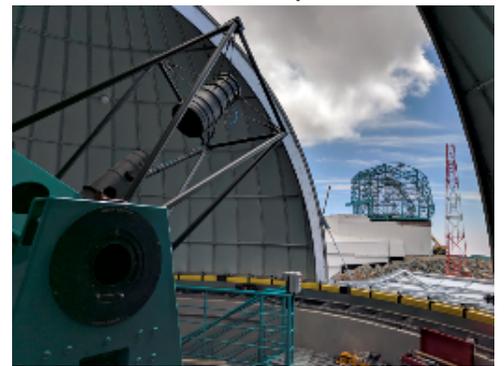
M1M3 Cart in transit

Coating chamber commissioning and verification in progress

Camera Progress Summary

5 mechanical rafts and 2 engineering rafts inserted in the production cryostat

L1 Edge treatment inspection

Production Manual Filter Loader

Crysotat introduced to Bench for Optical Testing (BOT)

Refrigeration system Commissioning

ComCam pin whole image

Data Management Progress Summary
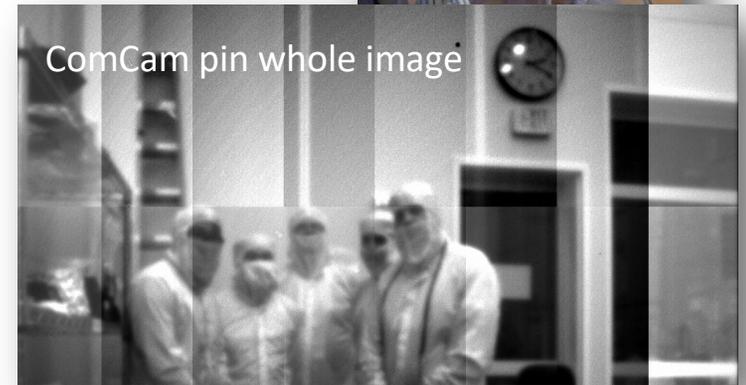
- – Level 2 milestone LDM-503-07 "Camera Data Processing". Demonstrated the successful transfer, ingest and processing of camera test stand data using the LSST Science Pipelines and Science Platform; as such, it represents a significant landmark in project integration.

- – Agreement for ESnet to provide two 100 gigabit/second dedicated fiber links from Atlanta to Chicago in FY21.

- – Release 17.1 of the LSST Science Pipelines.

- – Call for letters of intent for Community Brokers issued.

- – Authentication demonstrated in all parts of the Science Portal.

- – Cloud computing "proof of concept" in association with Google is concluding — study went very well! Now working on costing.

EPO work completed
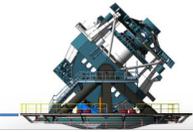
Understanding Concentration Maps

The map below shows a small section of the sky observed by LSST. Begin by selecting the star field image.
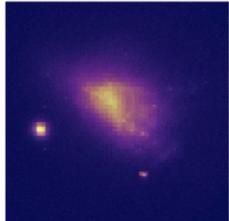
Concentration map —— Star field

Few   Many

When there are lots of stars in an image, it becomes impossible to quantify exactly how many stars are in a particular area just by looking at it. Since LSST will precisely map the locations of about 17 billion stars

Edge

Few   Many
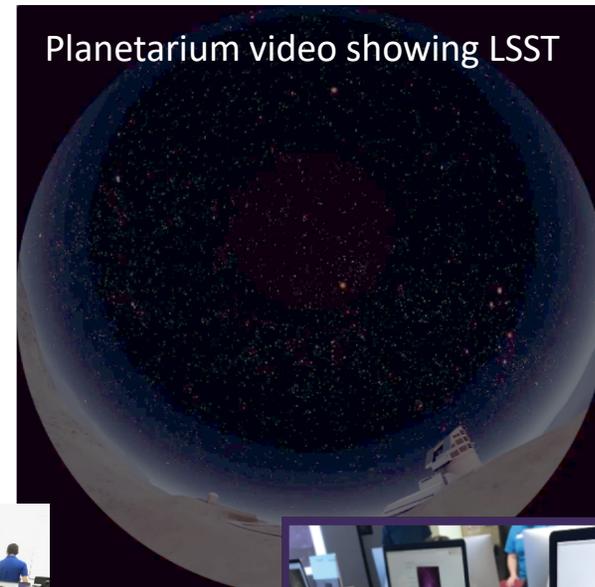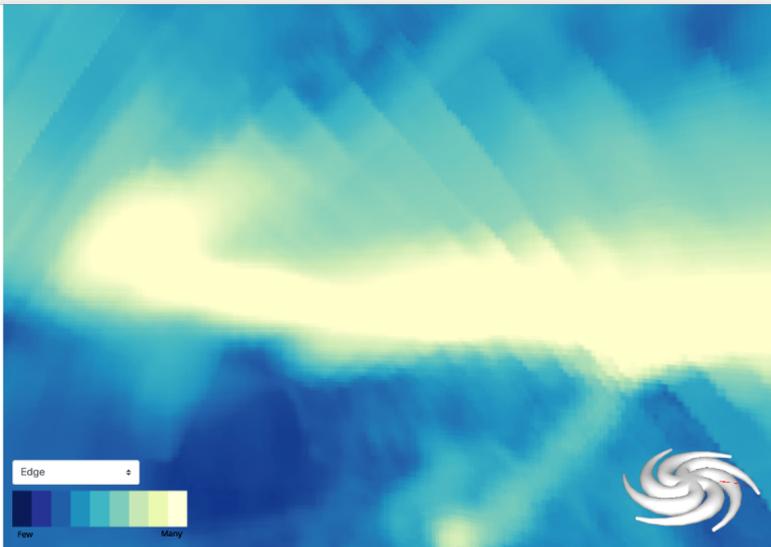
Planetarium video showing LSST

In *Mapping the Milky Way,* students use LSST's extensive sky coverage and object density to discover the shape of our Galaxy and where we live within it

First Spanish-language user testing at Chile summer school

Interactive website
Classroom investigations
Citizen science
LSST data--visualized!

EVMS Executive Summary – December 2018 Data

	MREFC - NSF	LSSTCam – DOE
% Complete (December 2018)	65	90
SPI	0.97	0.96
CPI	0.97	0.97
Contingency	$38.6 M	$9.4 M
Contingency after VAC	$19.4 M	$4.0 M
Work Remaining (BAC / EAC)	$154 M / $165 M	$16.6 M / $16.9 M
Contingency % Remaining Work (BAC / EAC)	25 / 11	57 / 24

LSST Project Schedule – 6 Months Contingency

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4

Data Management

Telescope & Site

Facility Support

Final DRP Release

Critical Path is Dome/TMA/AIV

Pre Commissioning Preparations

Com Cam on Summit

Engineering First Light

Early Integration & Testing

Camera

MIE to Ops

CD-4

Camera has 18 days of float - Cryostat

Full Integration & Verification

System First Light

Operational Readiness Review

+6 Schedule Contingency

Pre- Full Operations

Legend:
- NSF MREFC
- DOE MIE
- Commissioning
- Operations
- Critical Path

Construction Start

Now

Full System Integration "Start"

Science Operations Start

15 January 2019

Survey Strategy Planning

- Early in the LSST development effort, we created an Operations Simulator (OpSim) that simulated ten years of LSST observations using realistic assumptions about weather and seeing conditions.

- The initial strategy for the scheduler was to achieve uniform numbers of exposures in all filter bands across the southern hemisphere, optimizing the use of the night subject to a few programmatic constraints.

- Over time, more functionality was added to the scheduler to allow for selected "mini surveys" and to provide some flexibility in cadence strategy.

- This work demonstrated that much of the desired science for LSST could be achieved with the adopted technical design. Every part of the southern sky would be visited every few nights. We call this the "Wide, Fast, Deep" Survey (WFD).

Survey Strategy Planning

- However, through interactions with the community, it became clear that the "uniform cadence strategy" initially assumed in these studies is not optimal for some science investigations.

- In July 2018, we therefore issued a call for "white papers" from the community to suggest alternative survey strategies and to propose potential mini-surveys.

- The white papers were received in November 2018. They are being reviewed by the Science Advisory Committee. The purpose of the SAC review is to recommend a new set of OpSim runs to investigate alternative cadence strategies.

Survey Strategy Timeline

- Call for white papers: July 2018.

- White papers received: November 2018.

- SAC meeting to review WPs: January 2019.

- SAC recommendations for new OpSim runs: April 2019.

- Project completes new simulations and delivers them to the Survey Cadence Optimization Committee (SCOC): Early 2020.

- SCOC delivers recommendations to LSST Operations Director: Early 2021.

- Project delivers baseline simulation of initial survey strategy: Mid 2021.

- LSST begins operations: October 2022.

46 White Papers Received

- ~7 requests for varying WFD footprint - further north (low extinction footprint) or into galactic plane (galactic variability)

- ~10 requests for (different) cadences of visits in WFD
  - (lack of) visit gap requirements, rolling cadence
  - specify filters for pairs of visits; filters for triplets of visits

- 3 requests for WFD/all sky footprint minisurveys
  - 1-2 g band high airmass visits for DCR (AGN); short (5s) visits (photometric tie-in with Gaia); trailed (1s-15s) exposures (subsecond variability)

46 White Papers Received

- 3 ToO programs

- 3 co-observing with EUCLID or WFIRST

- 4 white papers on current/standard Deep Drilling fields
  - cadence of observations, u band depth, location of 5th field

- ~11 minisurvey suggestions
  - follow specific targets for limited (intense) periods of time

- 1 paper on NES (solar system), 2 on general 'northern' coverage (DESI, Euclid)
  - + short exposure, high X, twilight survey along ecliptic +/- 20deg (NEO)

- ~6 papers on galactic plane coverage, 1 on GP/SCP (stellar pops, variability, LMC/SMC)

46 White Papers Received

- Snap/visit exposure times:
    - Many prefer ~30s (1snap/visit) [7% more efficient]
    - But some still prefer 2x15s snaps - some in limited area only (white dwarf transits, rapid variability/saturation)
    - + 1 request for 2s/28s snaps
    - + minisurvey for 5s visits
    - + minisurvey for 1s-15s trailed images

Families of Simulations

- SRD requirements must be met (including 824 visits/18k sq deg)

- Basic footprints: old, new A, new B (3)

- Variations on cadence within the footprint

  - Rolling cadence (% rolling, area rolling)

    - Dec stripes (2 or 3?) and timing. RA stripes? Background? (x 6?)

  - Intra-night cadence

    - Pairs/no pairs, swapping filters or same filters (x4)

- Variations on DD - cadence and 5th field (x 3?)

- Must do snaps/no-snaps simulations for each (x2)

- Test impact of various mini-surveys on simulations (add/remove components)

Commissioning Data for Community

- The LSST Commissioning Team will generate data products from the observations taken in commissioning. The Commissioning team will verify, validate, and characterize these products, in order to test for the operations readiness of the system.

- The LSST Operations team plans to use the commissioning data products to develop and test its procedures for releasing, and then supporting the use of, LSST data.

- Preparing for each data release "scenario" in commissioning and science validation will take time and effort by the ops team.

Data Release Scenarios

- Scenario is a possible data release schedule or timeline

- Current plans include 3 scenarios for pre-operations (ComCam, LSSTCam, Mini Surveys)

- Release may start at flat files, will evolve to fully supported Data Access Center with LSP

- Plan to release data through LSP asap to gain operational experience and user feedback

- Early alert stream data will also be distributed, possibly with substantial latency, to familiarize the community with the planned format and content of the alert stream.

- At best-effort alert stream may be distributed around August 2021.

Scenarios

- ComCam Q3 2021
  - Data taking ends March 2021
  - Start releasing data (images) June 2021
  - Full data release Sept 2021
- LSSTCam Q3 2021
  - Data taking ends Sept 2021
  - Full data release March 2022
- Mini Surveys
  - 1-3 surveys
  - Data taking ends Dec 2021
  - Deliver first MS six months after finished (June 2022)

Summary Conclusion

- LSST Construction has been proceeding well. There have been some glitches along the way, but so far nothing has threatened our ability to meet or exceed our science requirements. We will deliver LSST on cost and on schedule.

- Contingencies are tight and we need to continue to aggressively manage the project to be successful.
    - Hardware is nearly 90% complete
    - Data Management is progressing well
    - Operations team is forming – Strong coordination with Construction

- The Project is engaging the community in optimizing the survey strategy.

- There will be opportunities for the community to gain experience with LSST data analysis through public release of commissioning data.