LARGE SYNOPTIC SURVEY TELESCOPE

NSF Monthly Progress Report

June 2019

For the period of performance May 1-31, 2019

Supported under CSA Award No: AST-1202910

GOVERNING COOPERATIVE AGREEMENT: 1258333

Submitted by:

Association of Universities for Research in Astronomy (AURA)

1212 New York Avenue NW

Suite 450

Washington, DC 20005

Technical Contact:

Victor Krabbendam, Project Manager

vkrabbendam@lsst.org

(520) 318-8482

(520) 881-2627

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Introduction

This technical progress report summarizes LSST activities for May 2019 accomplished with National Science Foundation (NSF) funding under Cooperative Support Agreement (CSA) award number AST-1202910 for construction of the Large Synoptic Survey Telescope (LSST) under the NSF Major Research Equipment and Facilities Construction (MREFC) account. The governing Cooperative Agreement (CA) for this effort is 1258333. This report is focused on the NSF construction effort but includes descriptions of work completed with Department of Energy (DOE) funding through contract DE-AC02-76-SF00515 with Stanford University. LSST is managed as a single coordinated effort. Descriptions of work completed with DOE funding are noted in *italics*, but no DOE-funded work is included in the report's financial data.

Document references in the text below indicate the documents' "handles" in the Project document archive, DocuShare. LSST's NSF Program Officer has access to the web-based, password-protected repository. Others may obtain access by contacting the LSST Project Manager.

1 Project Status

Overview

Project earned value (EV) toward the MREFC effort rose $9.1 million this month to a calculated $313.6 million. The cost variance (CV) changed $0.5 million this month to -$7.4 million, and the cost performance index (CPI) increased to 0.98. The schedule variance (SV) changed by -$0.5 million to -$5.5 million, which equates to a schedule performance index (SPI) of 0.98. There were 18 project controls change requests (LCRs) implemented this month; 12 had an impact on cost or schedule, resulting in a net contingency draw of $1,199,416. As of the end of the month, the Project has allocated 65% of the total contingency to the baseline through the change control process. The remaining contingency of $28.4 million is 22% of ETCI[1] (ETCI=BAC-BCWP[2]) and 21% of ETCII (monthly bottom up).

There are 51 control accounts beyond the plus/minus $100,000 reporting threshold contributing to the cost variance. The Dome Fabrication contract cost variance decreased from -$2.2 million to -$1.0 million. This decrease resulted partly from taking credit for a $750,000 payment made in April for a change order that wasn't implemented until May. The change order covered the cost of requirements changes for louvers and related structures. Also contributing to the overall CV are the expenses being paid directly by LSST to onsite vendors, principally crane vendor SIMAQ and erection labor support from MILL. There are 18 control accounts with a reportable schedule variance. The primary negative contributor is the 1.04C.14.04 Subsystem Integration and Test work breakdown structure (WBS) element at -$0.9 million. Dome and the Telescope Mount Assembly (TMA) subsystems delays are driving this schedule variance, as support effort that was planned to past periods is being delayed along with the major subsystem deliveries.

A new process for collecting and maintaining the ETCII has been implemented this month. This process utilizes the change control system to request modification to the ETCII above and beyond the baselined remaining work. This enables us to maintain the ETCII at a more detailed level and not constrained by an

[1] Estimate to complete
[2] Budgeted cost of work performed

exercise the project was running every six months. ETCII modifications that are approved by the project manager are integrated into the project schedule but under a different cost class code as the baselined budget. This allows for clear separation of what is in the BAC and what is in the ETCII. The ETCII is now remaining baseline work plus any manual adjustments made through the change control process.

Safety

LSST Safety activities focused on oversight at work sites, training, participation in the Coating Plant final review on the observatory site, oversight of the M1M3 (Primary-Tertiary Mirror) optic's transportation from Coquimbo port to the Cerro Pachón summit, and safety surveillance during successful M2 (Secondary Mirror) surrogate tests on the summit. The Safety team provided training and guidance for workers' safe travel to and from the summit during adverse weather. In particular, the team performed snow chains installation training, and an LSST Safety Recommendation provided guidance for monitoring tire tread wear. LSST personnel also participated in the fifth annual safety workshop for AURA's Cerro Pachón facilities' managers and supervisors. During the Coating Plant final review, Safety Coordinator S. Romero worked with the Coating team to perform hazards analysis. She also provided guidance and oversight during the planning for and actual transportation of M1M3 to the summit.

Two accidents were reported this month, resulting in either no or minor injuries. The first accident involved a Base Facility electrical contractor employee receiving an electrical shock resulting in visual dazzles. He was immediately transferred for medical care but has no lasting damage from the accident. In the second accident, a dump truck driver jumped out of the vehicle's cabin when it began to unexpectedly roll back toward the Cerro Pachón road's guard rail. The incident's cause is under investigation. The driver was uninjured, and the truck was undamaged; however, the truck blocked the road for a time, necessitating a temporary light vehicle bypass until it could be moved safely.

Quality and Compliance

The Compliance and Quality Administrator (CQA) is part of an AURA working group developing verification and compliance procedures for contractual requirements such as terms and conditions (T&Cs) and financial/administrative terms and conditions (FATCs). The CQA began auditing all fiscal year 2018 (FY18) travel expense reports for allowability and documentation support. In addition, the CQA provided guidance on temporary dependent care costs, information classification and travel.

Site Activity

Continuing Summit Facility post-construction projects included installation of bridge supports to connect the mirror cart rails to the Pflow platform lift, completion of improvements to the Camera clean/white room areas, electrical and data infrastructure improvements at the main and Auxiliary Telescope (AuxTel) facility, and initiation of road and platform improvements. The newly completed summit warehouse received the M1M3 optic 11 May. Subsequently, the mirror transport box was seismically anchored to the facility floor, and a contract to close the end wall was executed. The project also received two Dynalene chillers that were moved into the telescope pier where they will be installed in the future. Work continued on the Pachón hotel addition's main concrete structure; the project anticipates the addition will be complete and ready for LSST use by the end of August.

Dome Activity

LSST continues to closely monitor and assist in the advancement of all Dome construction activities. In

Chile, dome cladding installation began in parallel with continuing placement and adjustment of the steel structure's final pieces; however, on-site efforts were slowed by the arrival of winter weather. LSST management and engineers continued on-site assistance to vendor European Industrial Engineering (EIE), including management of purlins' and other structural pieces' procurement from Chilean fabricators. Change orders were enacted to incorporate design revisions and to facilitate procurement of remaining hardware components. At the vendor's Italian fabrication sites, the large louver panels were completed and shipped; fabrication of drives, overhead crane and other mechanisms continued.

With the TMA's pending on-site arrival in September, LSST and EIE have begun discussing ways to start TMA assembly in the event Dome substantial completion has yet to occur when the TMA arrives. Possible solutions include a provisional friction-drive system to allow dome rotation and a temporary bridge crane for mount assembly until the final bridge crane can be delivered.

Telescope and Site Subsystem

Vendor Asturfeito continued TMA disassembly, packing and shipping. Eight shipping containers of TMA components either have been received on-site in Chile or are now in overseas shipment. Updated overall schedules have been received and reviewed. The large bulk shipments of TMA components are now scheduled to be delivered to the port 19 July for subsequent shipment no later than 30 July. The M2 (Secondary Mirror) team completed integration and testing of the cell and surrogate at the Summit Facility. The M1M3 cart was successfully assembled and tested on-site during the week 13 May. An engineer from cart manufacturer CAID Industries helped oversee assembly, verified the operation and provided cart use instruction to the LSST team. In the first weeks of May, vendor Von Ardenne (VA) completed on-site assembly and testing of the Coating Plant. Final testing included performance verification with M2 and M1M3 witness samples. Base Facility construction progress included final testing of utility systems and development of a punch list for final finishes and interior/exterior details. Required Auxiliary Telescope (AuxTel) mount and dome mechanical work has been completed. To prepare for optics installation, the team performed installation and removal practice runs using surrogates. A contingent of the software team also successfully integrated and tested the AuxTel control system in Chile.

Data Management Subsystem

The team conducted the first DM Operations Rehearsal, during which a multi-institutional team, including members of the LSST Pre-Operations project, worked together to simulate nominal operational procedures over a three-day period. This included sending data from Chile to National Center for Supercomputing Applications (NCSA), processing it and performing quality assurance on the results. The team also made important LSST Science Platform (LSP) upgrades. Most significantly, the Firefly image display and portal system was upgraded to support a new service-discovery mechanism based on the Redis in-memory structured data store. This provides an alternative to the previous multicast-based approach, which was not well supported in cloud environments. Firefly also has been fully integrated into the Data Facility's authentication system. The Data Release Production group undertook an intensive "sprint" to integrate the SCARLET deblender with the rest of the code base. This is a key step toward verification and validation of the SCARLET system, which is a possible solution to the complex challenge of deblending LSST data in the operational era. A series of upgrades were made to the Alert Distribution system, focusing on more rigorous versioning of the alert schema and on providing user-friendly APIs to enable DM developers and external stakeholders to interact with LSST alerts.

Camera Subsystem

As reported last month, a serious injury accident that occurred 11 April has delayed integration of the filter exchange carousel with the back flange. Laboratoire de Physique Nucleaire et des Hautes Energies (LPNHE) has suspended carousel work while the incident is investigated and corrective actions are taken. A Camera project team visited LPNHE 22-24 May to review corrective safety measures and to evaluate the plan for carousel testing going forward. The person who was injured is recovering rapidly. The project expects that the incident will impact the carousel schedule by about two months; however, the carousel delay is not expected to impact Camera early delivery.

Brookhaven National Laboratory (BNL) continued phased-delivery of refurbished Raft Tower Modules (RTMs) to SLAC. Thus far, seven have been delivered to the SLAC IR2 cleanroom facility. Delivery is expected to continue into the third quarter of 2019. Two of the four focal plane corner RTMs (CRTMs) have completed acceptance testing. The Corner Raft team is on track to complete CRTM testing in July as planned.

Vendor Arizona Optical Systems (AOS) attached the L1 lens to the L1-L2 assembly. Transmitted wavefront error (TWE) testing of the integrated assembly showed more astigmatism than expected, but the project expects to address the issue by modifying shims that adjust L1-to-L2 alignment. The first units of the production auto-changer and filter loader have been shipped for combined testing at LPNHE. Assembly of the Camera body housing and Camera body shroud is nearly complete. As previously reported, production shutter assembly will be delayed due to long lead time for delivery of the shutter blade guides, which are custom-made in Japan. The project is taking steps to expedite delivery from the vendor. The shutter delay will not impact Camera schedule or cost.

Four power cabling feedthroughs and all six optical translation modules (OTMs) were installed on the cryostat assembly. The power feedthroughs and two OTMs are required for final testing of bench for optical testing (BOT) electro-optical (EO) instrumentation. All Integration and Test (I&T) heat exchangers and refrigeration cabinets are now operating at IR2, and verification tests of the entire I&T refrigeration system is underway. Verification of I&T refrigeration is another prerequisite for final EO testing, which requires a cold cryostat.

Education and Public Outreach

The Education and Public Outreach (EPO) team completed work on the *Exploding Stars* and *A Window to the Stars* web-based formal education investigations. The team also planned detailed work to be done in FY20, began planning for Alert Stream web displays, and created an inventory of video resources produced by EPO, including 20 full-dome planetarium resources and documentation. EPO welcomed new Senior Web Developer B. Mason and said goodbye to developer A. Yacoe.

Near Term Events and Meetings

A formal list of Level 1 milestones is provided in Section 3. Below is a list of key items on the Project Manager's watch list for the next few reporting periods.

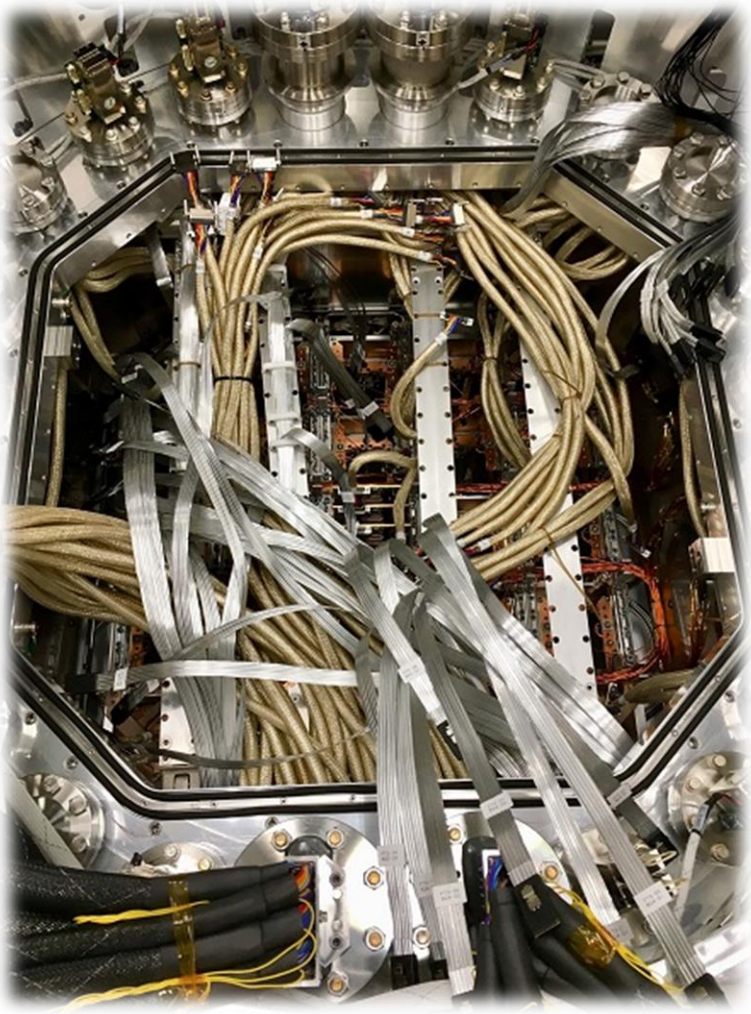
- American Astronomical Society (AAS) Meeting – 9-13 June
- Commissioning Science Verification Test Specifications workshop – 10-12 June
- Community Broker Workshop – 19-21 June
- Project Science Team (PST) meeting – 1-2 July

- Director's Review for NSF/DOE Joint Status Review (JSR) – 6-9 August
- LSST2019 Project and Community Workshop – 12-16 August
- NSF/DOE JSR – 27-30 August
- TMA On-Site Test Plan Review – 9-14 September
- Data Management Leadership Team (DMLT) meeting – 29-31 October

2 Current Photos

Vendor Von Ardenne (VA) completed on-site assembly and testing of the Coating Plant. Final testing included performance verification with M2 (Secondary Mirror) and M1M3 (Primary-Tertiary Mirror) witness samples. In the photo above, the M2 surrogate is being placed under the coating chamber for testing. Then the plant was reconfigured for the M2 mirror, which in mid-July will be the first LSST optic to receive its coating for operational scientific use.

The photos above provide two views of the nearly completed Base Facility in La Serena Chile. At top, the main entrance is shown. The photo below highlights the façade with a graphic depicting a panoramic mountain vista and Cerro Pachón's observatory residents.

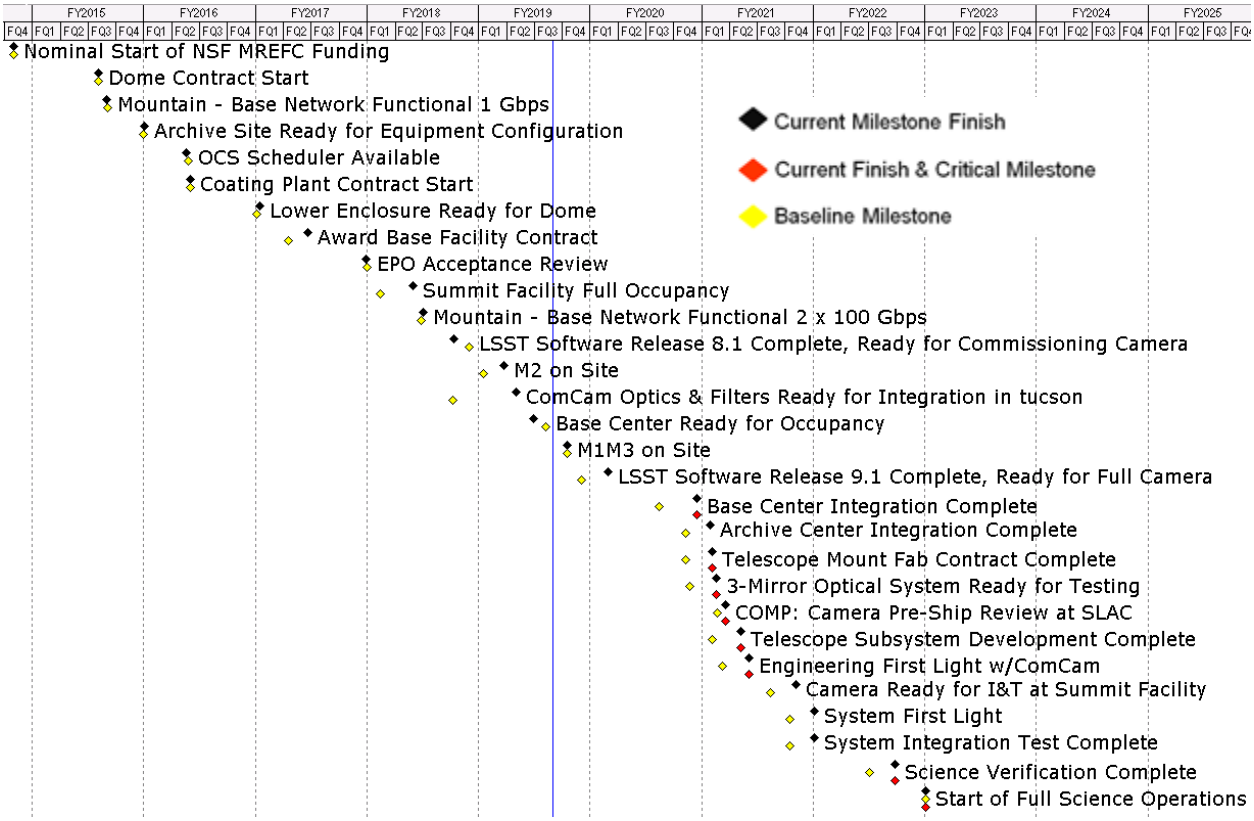


A view into the top of the LSST camera cryostat during installation of optical translation modules (OTMs) and utility trunk power-cabling feedthroughs. OTMs translate the raft tower modules' (RTMs) electrical signals into optical signals to be processed off-camera. Power feedthroughs provide power to readout electronics boards (REBs) within the rafts. The OTMs and feedthroughs are installed on the feedthrough plate on the perimeter of the cryostat. Here, the silver-colored flat leads are part of the OTMs. The wax-colored cabling bundles are part of the power feedthroughs. All six OTMs required for the camera are now installed. Four of 10 power feedthroughs have been installed, but those four are all that are required for this stage of testing at SLAC's IR2 cleanroom facility.

3 Project Integrated Schedule

Efforts toward getting the entire M1M3 system on the summit is still progressing well. The M1M3 mirror arrived on site 11 May after beginning its eight-week journey 15 March in Tucson, where it was fabricated. The M1M3 cell is right behind the mirror and should be in Coquimbo late June. The current shipping plan is to wait until after the eclipse to start transportation of the cell to the summit on 7 July. The Base Center completion is slipping, but the critical element for the schedule is the Data Center, and that part has been completed and delivered to LSST. The remaining elements are the office spaces and electrical work. While this is progressing, there are delays due to the city schedule for the main electrical feed connection. This is not anticipated to be an issue, and work will stay ahead of the critical path.

Level 1 Milestones



Level 1 Milestone Change Tracking

Activity Name	Baseline Finish	Previous Month Finish	Forecast / Actual Finish	Delta From Baseline	Delta From Previous Month	Total Float
Nominal Start of NSF MREFC Funding	1-Aug-14	01-Aug-14 A	01-Aug-14 A	0	0	0
Dome Contract Start	4-May-15	04-May-15 A	04-May-15 A	0	0	0
Mountain - Base Network Functional 1 Gbps	2-Jun-15	01-Jun-15 A	01-Jun-15 A	-1	0	0
Archive Site Ready for Equipment Configuration	29-Sep-15	01-Oct-15 A	01-Oct-15 A	2	0	0
OCS Scheduler Available	24-Feb-16	15-Feb-16 A	15-Feb-16 A	-7	0	0

Coating Plant Contract Start	1-Mar-16	01-Mar-16 A	01-Mar-16 A	0	0	0
Lower Enclosure Ready for Dome	5-Oct-16	14-Oct-16 A	14-Oct-16 A	7	0	0
Award Base Facility Contract	17-Jan-17	20-Mar-17 A	20-Mar-17 A	43	0	0
EPO Acceptance Review	29-Sep-17	28-Sep-17 A	28-Sep-17 A	-1	0	0
Summit Facility Full Occupancy	13-Nov-17	01-Mar-18 A	01-Mar-18 A	72	0	0
Mountain - Base Network Functional 2 x 100 Gbps	27-Mar-18	02-Apr-18 A	02-Apr-18 A	2	0	0
LSST Software Release 8.1 Complete, Ready for Commissioning Camera	31-Aug-18	12-Jul-18 A	12-Jul-18 A	-37	0	0
M2 on Site	18-Oct-18	23-Dec-18 A	23-Dec-18 A	47	0	0
ComCam Optics & Filters Ready for Integration in Tucson	9-Jul-18	1-Feb-19 A	1-Feb-19 A	143	0	0
Base Center Ready for Occupancy	7-May-19	29-Mar-19 A	29-Mar-19 A	-28	0	0
M1M3 on Site	18-Jul-19	9-Aug-19	18-Jul-19	0	-16	128
LSST Software Release 9.1 Complete, Ready for Full Camera	3-Sep-19	3-Sep-19	27-Nov-19	62	62	208
Telescope Mount Fab Contract Complete	7-Aug-20	28-Oct-20	2-Nov-20	60	3	-61
Base Center Integration Complete	13-May-20	3-Jul-20	15-Sep-20	87	52	-7
3-Mirror Optical System Ready for Testing	24-Aug-20	12-Nov-20	17-Nov-20	60	3	-43
Telescope Subsystem Development Complete	5-Nov-20	1-Feb-21	4-Feb-21	60	3	-61
Engineering First Light w/ComCam	7-Dec-20	2-Mar-21	5-Mar-21	60	3	-28
Archive Center Integration Complete	7-Aug-20	28-Oct-20	28-Oct-20	57	0	280
COMP: Camera Pre-Ship Review at SLAC	19-Nov-20	19-Nov-20	16-Dec-20	17	17	-3
Camera Ready for I&T at Summit Facility	13-May-21	30-Jul-21	4-Aug-21	59	3	86
System First Light	16-Jul-21	1-Oct-21	6-Oct-21	57	3	123
System Integration Test Complete	16-Jul-21	1-Oct-21	6-Oct-21	57	3	123
Science Verification Complete	1-Apr-22	21-Jun-22	24-Jun-22	60	3	-61
Start of Full Science Operations	3-Oct-22	3-Oct-22	3-Oct-22	0	0	0

3.1 Critical Path

The critical path continues to be under stress. The forecast delay remains at three months, and efforts to reduce the schedule are being met with equal and opposite impacts as we progress. The System Integration re-planning has been going very well. This optimization of the integration work combines the remaining Telescope and Site AIV (WBS 1.04C.14) work with the System Integration work (WBS 1.06C.03). As the plan is finalized, a change request will be issued and it will meet the threshold for NSF approval.

See Section 6 for the critical path plots.

4 Financial Summary and Projections

4.1 Brief Narrative

To date the Project has received $372.5 million of MREFC funding and has incurred approximately $321.0 million in actual costs (31 May 2019). EV is calculated at $313.6 million with details presented in Section

4.4. Using Monte-Carlo risk-based methods, LSST has calculated that a total contingency of $82.4 million dollars is necessary for 90% confidence in completing the project; this has been agreed with NSF. A net total of $54.0 million in contingency has been allocated to the distributed budget through the change control process with a current BAC of $442.7 million.

For the MREFC project, the CV is -$7.4 million (2%), and the SV is -$5.5 million (2%). This equates to a CPI of 0.98 and an SPI of 0.98.

In April 2018, the integrated Monte Carlo assessment using the resource loaded schedule and risk register impacts determined the project had an 88% confidence in completing within the available contingency. A revised analysis will be completed in June 2019.

4.2 Funding Profile Table

LSST MREFC Funding Profile (CSA Update 12-Feb-2019)										
	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	Grand Total
Approved Budget	$21,139,502	$71,055,610	$78,323,209	$59,986,864	$44,774,121	$39,535,210	$41,681,902	$32,261,258	$0	**$388,757,676**
Approved Contingency	$6,360,498	$8,584,440	$21,346,718	$7,318,744	$12,256,014	$9,012,017	$4,383,062	$8,239,703	$4,891,803	**$82,392,999**
Management Fee	$0	$0	$12,837	$191,949	$284,662	$284,662	$284,662	$284,662	$0	**$1,343,434**
Total	**$27,500,000**	**$79,640,050**	**$99,682,764**	**$67,497,557**	**$57,314,797**	**$48,831,889**	**$46,349,626**	**$40,785,623**	**$4,891,803**	**$472,494,109**
Authorized Budget	$21,400,000	$70,795,062	$78,323,209	$59,986,864	$44,774,121	$39,535,260	$0	$0	$0	**$314,814,516**
Authorized Contingency	$6,100,000	$8,844,938	$14,633,954	$0	$21,641,187	$5,646,335	$0	$0	$0	**$56,866,414**
Authorized Management Fee	$0	$0	$12,837	$191,949	$284,662	$284,662	$0	$0	$0	**$774,110**
Total	**$27,500,000**	**$79,640,000**	**$92,970,000**	**$60,178,813**	**$66,699,970**	**$45,466,257**	**$0**	**$0**	**$0**	**$372,455,040**

Note: The funding table has been updated to reflect the NSF-approved management fee proposal (1758427). The NSF determined a fee of $284,662 for fiscal year 2018 (FY18) and each of the subsequent years remaining under the CSA, with the exception of the final year, which is to be renegotiated for approval under the LSST Operations award.

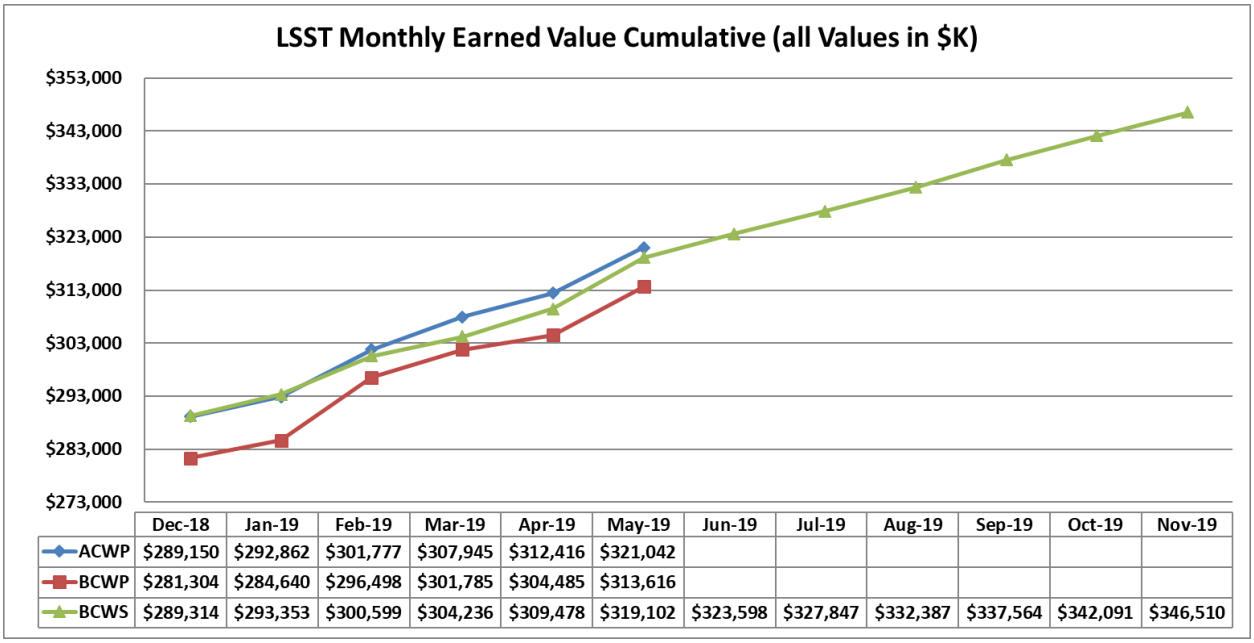
4.3 Top Level Earned Value Management (EVM) Data Table and "S" Curve

		$M
EVM Reporting Date		May-19
Total Project Cost (TPC - $M) (Includes Mgmt fee)		472.5
Estimate At Completion (EACI - $M)		450.2
Estimate At Completion Bottom Up (EACII - $M)		455.5
Budget at Completion (BAC - $M)		442.7
Budgeted Cost of Work Scheduled (BCWS - $M)		319.1
Budgeted Cost of Work Performed (BCWP - $M)		313.6
Actual Cost of Work Performed (ACWP - $M)		321.0
Remaining Contingency		28.4
Remaining Contingency, % of ETCI		22%
Remaining Contingency, % of ETCII		21%
% complete	Planned	72%
	Actual	71%
% $	Percent Spent	73%
Cost Variance (CV)		-7.4

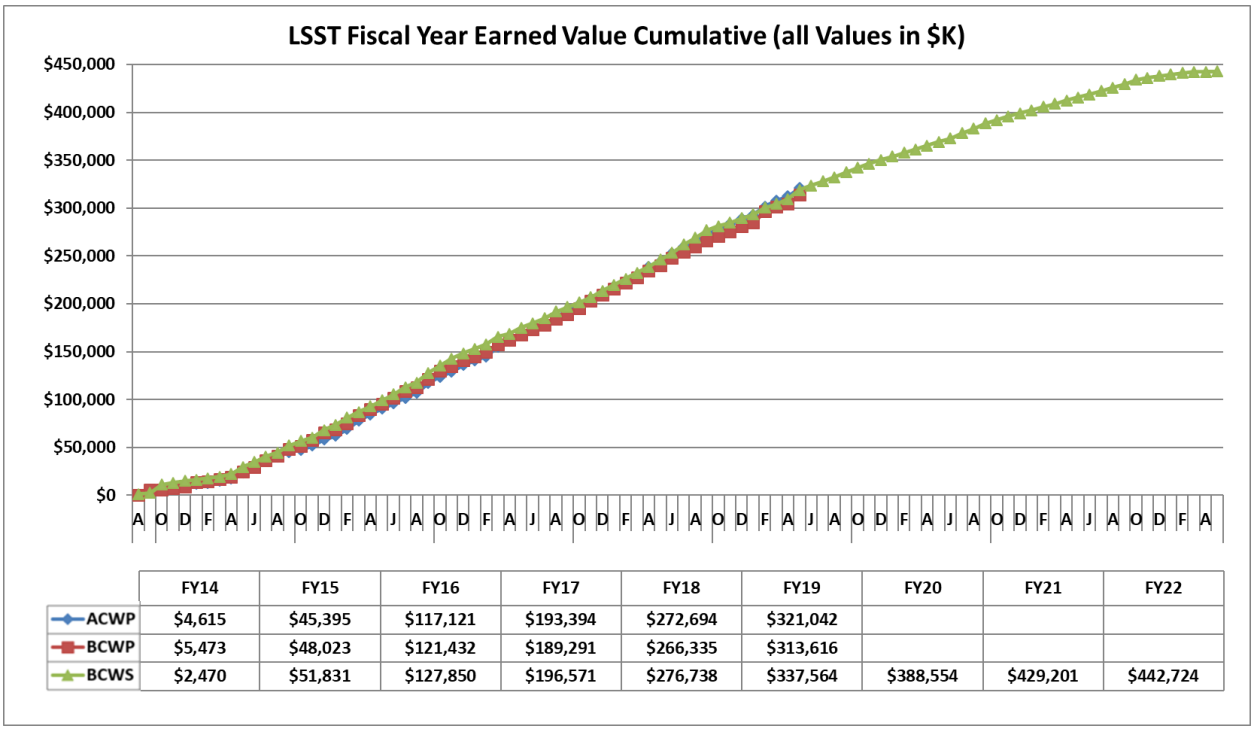
EACI=ACWP+BAC-BCWP

Schedule Variance (SV)	-5.5
Actuals + Commitments (Approx.)	363.0
Cumulative NSF funding to date	372.5

Note: The EACII is now managed on a monthly time frame to determine the Estimate at Completion (EAC).



	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19
ACWP	$289,150	$292,862	$301,777	$307,945	$312,416	$321,042						
BCWP	$281,304	$284,640	$296,498	$301,785	$304,485	$313,616						
BCWS	$289,314	$293,353	$300,599	$304,236	$309,478	$319,102	$323,598	$327,847	$332,387	$337,564	$342,091	$346,510



	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22
ACWP	$4,615	$45,395	$117,121	$193,394	$272,694	$321,042			
BCWP	$5,473	$48,023	$121,432	$189,291	$266,335	$313,616			
BCWS	$2,470	$51,831	$127,850	$196,571	$276,738	$337,564	$388,554	$429,201	$442,724

EV Summary of the Project Down to Level 2 of the Work Breakdown Structure (WBS).

The following EV summary table now contains columns to show SPI and CPI indices for each WBS.

	CPR REPORT MONTH ENDING 5/31/2019 (ALL VALUES IN $K)																
	CURRENT PERIOD							CUMULATIVE TO DATE							AT COMPLETE			
	PLANNED	EARNED	ACTUAL	SV	CV	SPI	CPI	PLANNED	EARNED	ACTUAL	SV	CV	SPI	CPI	BAC	EAC	VAC	PCT COMP
1 LSST Construction Baseline	9,624	9,131	8,626	-493	504	0.95	1.06	319,102	313,616	321,042	-5,486	-7,427	0.98	0.98	442,724	450,151	-7,427	70.8 %
1.01C Project Management Office Construction	519	499	733	-20	-234	0.96	0.68	34,587	34,566	36,375	-20	-1,809	1.00	0.95	47,660	49,469	-1,809	72.5 %
1.02C Data Management Construction	6,446	2,288	2,309	-4,158	-22	0.35	0.99	88,798	86,292	86,010	-2,505	282	0.97	1.00	147,218	146,937	282	58.6 %
1.04C Telescope and Site Construction	2,377	6,020	5,294	3,643	726	2.53	1.14	181,925	179,075	185,675	-2,850	-6,600	0.98	0.96	205,833	212,433	-6,600	87.0 %
1.05C Education and Public Outreach Construction	85	89	108	4	-19	1.05	0.82	4,131	4,049	3,988	-82	61	0.98	1.02	9,185	9,124	61	44.1 %
1.06C Systems Engineering and Commissioning	197	235	182	38	53	1.19	1.29	9,662	9,633	8,994	-29	639	1.00	1.07	32,828	32,189	639	29.3 %

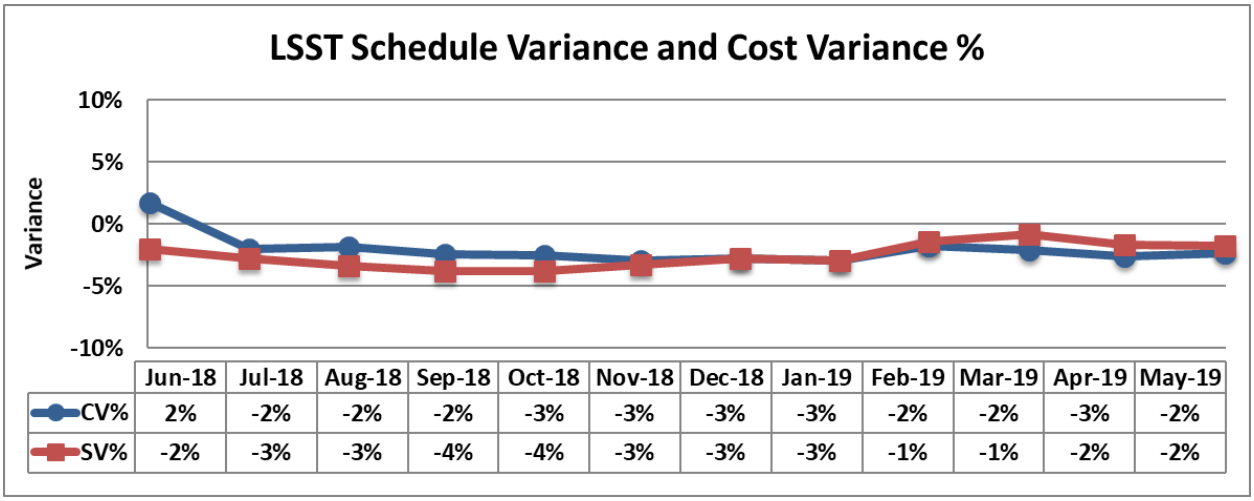
4.4 WBS Sub-System Level EVM

	CPR REPORT MONTH ENDING 5/31/2019 (ALL VALUES IN $K)																
	CURRENT PERIOD							CUMULATIVE TO DATE							AT COMPLETE			
	PLANNED	EARNED	ACTUAL	SV	CV	SPI	CPI	PLANNED	EARNED	ACTUAL	SV	CV	SPI	CPI	BAC	EAC	VAC	PCT COMP
1.01C.01 LSST Project Office	347	347	429	0	-82	1.00	0.81	19,580	19,580	20,012	0	-432	1.00	0.98	27,525	27,958	-432	71.1 %
1.01C.02 Site Office	47	47	89	0	-42	1.00	0.53	3,027	3,027	3,986	0	-960	1.00	0.76	4,476	5,436	-960	67.6 %
1.01C.03 Safety and Environmental Assurance	19	19	41	0	-22	1.00	0.46	1,553	1,553	1,496	0	58	1.00	1.04	2,418	2,361	58	64.2 %
1.01C.04 Facility and Staff Administration	31	31	55	0	-23	1.00	0.57	3,416	3,416	3,811	0	-395	1.00	0.90	4,392	4,787	-395	77.8 %
1.01C.05 AURA	75	55	119	-20	-65	0.73	0.46	7,010	6,990	7,070	-20	-80	1.00	0.99	8,848	8,928	-80	79.0 %
1.02C.01 System Management	73	73	84	0	-11	1.00	0.87	5,203	5,203	5,082	0	121	1.00	1.02	6,938	6,817	121	75.0 %
1.02C.02 System Engineering	151	151	184	0	-32	1.00	0.82	6,034	6,034	6,339	0	-305	1.00	0.95	9,496	9,801	-305	63.5 %
1.02C.03 Alert Production	145	161	124	16	37	1.11	1.30	6,163	6,025	6,116	-138	-90	0.98	0.99	11,495	11,585	-90	52.4 %
1.02C.04 Data Release Production	208	250	178	42	72	1.20	1.41	8,194	7,640	7,024	-554	616	0.93	1.09	17,493	16,876	616	43.7 %
1.02C.05 Science User Interface and Analysis Tools	24	65	100	41	-35	2.69	0.65	7,627	7,499	7,362	-128	138	0.98	1.02	8,667	8,529	138	86.5 %
1.02C.06 Science Data Archive and Application Services	176	290	192	114	98	1.65	1.51	9,409	8,841	8,983	-568	-143	0.94	0.98	13,052	13,195	-143	67.7 %
1.02C.07 Processing Control and Site Infrastructure	389	398	407	9	-9	1.02	0.98	18,401	17,942	17,823	-460	118	0.98	1.01	42,122	42,003	118	42.6 %
1.02C.08 International Communications and Base Site	5,203	831	956	-4,371	-124	0.16	0.87	24,400	23,826	24,059	-575	-233	0.98	0.99	30,487	30,720	-233	78.2 %
1.02C.09 Data Management System Integration and Test	0	0	0	0	0	0	0	0	0	3	0	-3	0	0	815	817	-3	0.0 %
1.02C.10 Science Quality and Reliability Engineering	77	67	85	-10	-18	0.87	0.79	3,366	3,282	3,221	-83	61	0.98	1.02	6,654	6,592	61	49.3 %
1.04C.01 Telescope System Management	354	333	275	-21	58	0.94	1.21	8,771	8,756	8,976	-15	-220	1.00	0.98	16,302	16,521	-220	53.7 %
1.04C.02 Telescope System Engineering	0	0	0	0	0	0	0	1,533	1,533	1,624	0	-91	1.00	0.94	1,533	1,624	-91	100.0 %
1.04C.03 Summit Facilities and Infrastructure	68	0	61	-68	-61	0	0	36,180	36,106	36,283	-74	-177	1.00	1.00	36,180	36,357	-177	99.8 %
1.04C.04 Dome	1,450	1,924	727	474	1,197	1.33	2.65	16,507	16,184	17,542	-323	-1,359	0.98	0.92	17,728	19,086	-1,359	91.3 %
1.04C.05 Telescope Mount	0	0	20	0	-20	0	0	36,556	36,556	36,750	0	-194	1.00	0.99	39,083	39,278	-194	93.5 %
1.04C.06 Mirror Systems	0	100	36	100	64	0	2.80	28,191	27,915	29,357	-276	-1,441	0.99	0.95	28,206	29,648	-1,441	99.0 %
1.04C.07 Wavefront and Alignment Sensing	0	0	0	0	0	0	0	605	605	557	0	48	1.00	1.09	605	557	48	100.0 %
1.04C.08 Calibration System	64	91	91	27	0	1.43	1.01	4,560	4,480	4,385	-79	95	0.98	1.02	6,033	5,938	95	74.3 %
1.04C.09 Reflective Coating System	0	2,479	2,451	2,479	28	0	1.01	18,887	18,887	19,074	0	-187	1.00	0.99	19,157	19,344	-187	98.6 %
1.04C.10 Observatory Control System	0	0	0	0	0	0	0	4,038	4,038	4,190	0	-151	1.00	0.96	4,038	4,190	-151	100.0 %
1.04C.11 Telescope Control System	0	0	0	0	0	0	0	2,704	2,704	2,796	0	-92	1.00	0.97	2,704	2,796	-92	100.0 %
1.04C.12 Utilities and Support Equipment	134	877	1,010	743	-133	6.54	0.87	9,169	8,718	9,278	-450	-559	0.95	0.94	11,023	11,582	-559	79.1 %
1.04C.13 Base Facility and Infrastructure	18	18	265	0	-247	1.00	0.07	8,943	8,689	10,422	-255	-1,733	0.97	0.83	9,159	10,892	-1,733	94.9 %
1.04C.14 Telescope Integration and Test	195	148	218	-47	-70	0.76	0.68	4,311	3,182	3,829	-1,129	-646	0.74	0.83	9,217	9,864	-646	34.5 %
1.04C.15 Telescope and Site software	95	51	141	-44	-90	0.54	0.36	970	722	613	-247	109	0.74	1.18	4,865	4,756	109	14.8 %
1.05C.01 System Management	26	26	32	0	-6	1.00	0.82	1,991	1,991	1,888	0	103	1.00	1.05	3,334	3,231	103	59.7 %
1.05C.02 EPO Database and Data Access Services	0	52	0	52	52	0	126.60	474	474	468	0	6	1.00	1.01	526	520	6	90.1 %
1.05C.03 Infrastructure for Citizen Science	0	0	38	0	-38	0	0	125	124	154	-1	-30	0.99	0.80	282	312	-30	44.0 %
1.05C.04 Classroom / Online Research Toolkit	31	12	25	-19	-13	0.38	0.47	579	562	486	-18	75	0.97	1.15	2,057	1,981	75	27.3 %
1.05C.05 Visualization including Science Museums	15	0	0	-15	0	0	0	460	410	488	-50	-78	0.89	0.84	856	934	-78	47.9 %
1.05C.06 User Interfaces	12	-1	13	-14	-14	-0.12	-0.11	502	488	503	-14	-15	0.97	0.97	2,130	2,145	-15	22.9 %
1.06C.01 Systems Engineering Management	82	82	54	0	28	1.00	1.53	6,957	6,949	6,820	-8	129	1.00	1.02	10,058	9,929	129	69.1 %
1.06C.02 Commissioning	115	153	128	38	25	1.33	1.20	2,705	2,684	2,174	-20	510	0.99	1.23	22,771	22,260	510	11.8 %

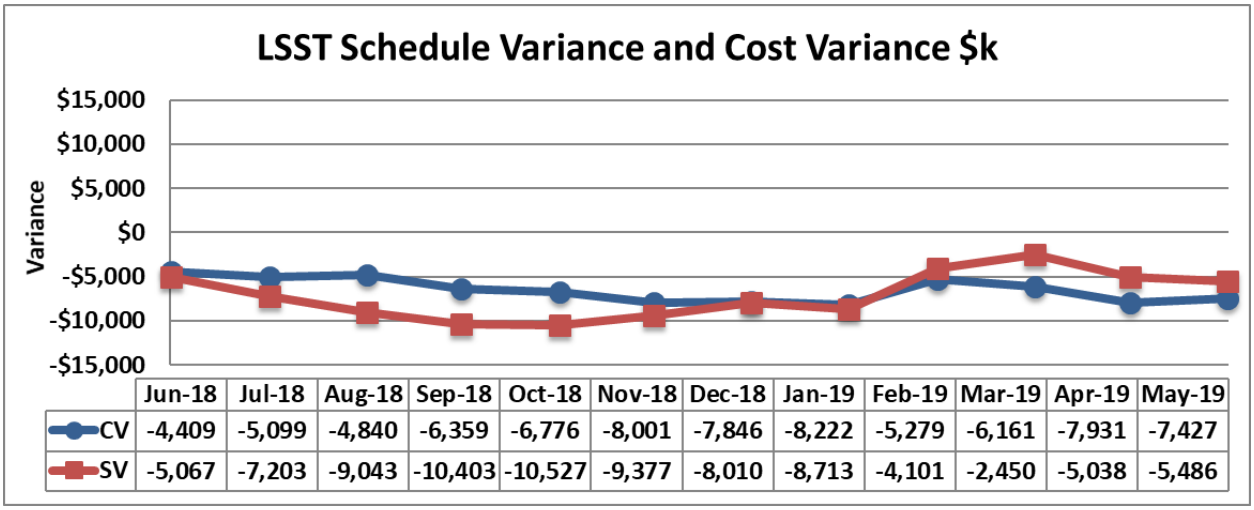
4.5 Schedule Variance (SV) and Cost Variance (CV) Trend Graph

Project financial data are provided through 31 May. The trend graphs for the last 12 months of the project duration are provided below. See sections 4.1, above, and 4.6, below, for narratives on variances and

recovery plans. The first graph provides cost and schedule variances as percentages; the second graph shows the same variance data in dollars.



	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19
CV%	2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-2%	-2%	-3%	-2%
SV%	-2%	-3%	-3%	-4%	-4%	-3%	-3%	-3%	-1%	-1%	-2%	-2%



	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19
CV	-4,409	-5,099	-4,840	-6,359	-6,776	-8,001	-7,846	-8,222	-5,279	-6,161	-7,931	-7,427
SV	-5,067	-7,203	-9,043	-10,403	-10,527	-9,377	-8,010	-8,713	-4,101	-2,450	-5,038	-5,486

4.6 Discussion of Variances and Corrective Actions

The following is provided at the WBS level of the data reported in Section 4.4.

	CUMULATIVE TO DATE (K$)					
	PLANNED	EARNED	ACTUAL	SV	CV	BAC
1.01C.01.01 LSST Project Office	13,814	13,814	13,927	0	-114	19,102
Explanation: The -$114 CV is a result of increased travel in FY19. The original budget planned a total of $145k for travel in FY19. As of May we have already spent close to that amount in travel.						
Corrective Action: We have had increased travel due to increased management of Dome, TMA, and Chilean						

site activities. For now, we will continue to keep an eye on the CV and will find opportunities where we can reduce future travel to recover costs.						
1.01C.01.02 Chief Scientist Support	**1,098**	**1,098**	**1,269**	**0**	**-171**	**1,835**
Explanation: The Cost variance changed from -$159k to -$171k. This cost variance is the result of underestimating the effort the Chief Scientist in FY18.						
Corrective Action: We assessed the past increased level of effort required to support LSST in our first FY19 EAC exercise and we believe that the remaining budget will be appropriate to support the remaining work for this work package.						
1.01C.01.05 LSST Project Science	**1,786**	**1,786**	**1,936**	**0**	**-150**	**1,899**
Explanation: The cost variance under LSST Project Science has a cumulative cost variance of -$150k. The cost variance is attributed to the promotion of Zeljko Ivezic to the deputy director.						
Corrective Action: Additional budget will be added to this work package in an upcoming LCR.						
1.01C.02.01 Site Office	**3,027**	**3,027**	**3,986**	**0**	**-960**	**4,476**
Explanation: The negative cost variance of -960K has been caused by underestimating the available budget to fund the additional road improvements at LSST entry to the summit.						
Corrective Action: Additional budget will need to be drawn from contingency to fund the remaining road improvement effort.						
1.01C.04.01 Facility	**2,776**	**2,776**	**3,048**	**0**	**-272**	**3,752**
Explanation: The cost variance continues to worsen by -~20K a month and is now at -272K cumulative. The building lease budget was underestimated for FY18, mainly due to the large increase of telescope and staff software staff from budget (50% increase). The FY19 budget assumes a ramp down of Tucson lease staff which is now beginning to happen.						
Corrective Action: With the transition of staff to Chile and planned staff reductions in some subsystems we expect these facility costs to better match the FY19 budget. We are running projections of staffing to get a better estimate of budget needed for FY19. The lease on the "penthouse" for the software team is coming to an end as software staff relocate to the engineering area and Chile which will decrease monthly actuals. The ramp down of office space is beginning, just a little later than planned.						
1.01C.04.02 Staff Administration	**640**	**640**	**763**	**0**	**-123**	**640**
Explanation: This Staff Administration and Recruiting Professional Services account was slightly under budgeted by 123K leading to the negative cost variance. This account is closed.						
Corrective Action: No corrective action. This control account is now closed with a cost variance of -$123k.						

1.02C.02.01 Data Management Science	**2,517**	**2,517**	**2,703**	**0**	**-186**	**3,812**
Explanation: The LOE budget for KLM20201A.PROC remains under-budgeted for two University of Washington Project Science Analysts who have been assigned to this work package.						
Corrective Action: An LCR will be submitted next month (June) to redistribute future budgets and I&T budgets associated with this scope of work.						
1.02C.02.02 Data Management Architecture	**3,516**	**3,516**	**3,635**	**0**	**-119**	**5,684**
Explanation: This variance is getting worse by about -$10k a month, however there is ample budget in the future to cover this small overspend.						
Corrective Action: An LCR will be submitted to use future funds to rectify this shortfall.						
1.02C.03.05 Tools for Science Pipelines	**1,009**	**989**	**819**	**-20**	**170**	**1,796**
Explanation: The accumulated cost variance in this account is due to lower than expected effort required to address emergent issues during late calendar 2018 and early 2019.						
Corrective Action: Savings here will be offset against future emergent issues.						
1.02C.03.07 Transform Fitting on Stacks of Images	**124**	**120**	**234**	**-4**	**-114**	**738**
Explanation: Cumulative cost variance in this element is due to higher than anticipated integration costs of the Jointcal photometric calibration system. This was hampered by failures of the algorithm when applied to data from precursor facilities and required greater than anticipated effort to overcome. Note that this cost variance is now contained, and Jointcal is in regular use within Science Pipelines verification & validation.						
Corrective Action: Photometric Jointcal integration is now complete; no further cost is expected for this work. The difficulties encountered with Jointcal are being mitigated by exploiting the Forward Global Calibration Method (FGCM), an alternative technique which can address broadly the same problem domain. Initial work with FGCM has progressed smoothly, and we expect it to address remaining photometric Jointcal use cases at a lower development cost than using Jointcal itself. Jointcal development will continue to address astrometric calibration only, reducing the overall load on this account.						
1.02C.03.08 Integration	**244**	**244**	**369**	**0**	**-125**	**578**
Explanation: No work was performed in this WBS element during May. We continue to carry a cost variance from some early integration activities charged to this account in 2018.						
Corrective Action: The early integration activities will pay off when scheduled work in this element starts; later activities will progress with lower than previously-estimated costs, recovering the variance.						
1.02C.04.02 Calibration Products	**807**	**702**	**495**	**-105**	**207**	**1,903**

Explanation: Cost variance here is due to incorrect resource loading at the start of the S19 cycle causing the value of the work being performed to be overestimated. Schedule variance is due to: - Late closure of DM-16685 and DM-16686. - Slow progress on DM-18006 due to resources being diverted elsewhere.						
Corrective Action: An LCR will be submitted to reduce the value of the activities being carried out, and hence to reduce the cost variance. DM-16685 and DM-16686 have now been completed. DM-18006 remains a high priority, with a particular focus on the Dark Energy Science Collaboration meeting in early July.						
1.02C.04.05 Detection & Deblending	**442**	**411**	**295**	**-31**	**116**	**2,328**
Explanation: Positive cost variance in this WBS is driven by: - Over-estimation of rates being charged for work in KLM20405B. - Over-estimation of the cost of work being performed in KLM20405A.						
Corrective Action: The T/CAM will work with the Project Controls Specialist to resolve accounting issues						
1.02C.04.07 Maintenance, Quality & Documentation	**637**	**548**	**286**	**-89**	**262**	**1,514**
Explanation: Positive cost variance in this WBS is driven by: - Fewer than expected emergent issues being encountered. - Over-estimation of the cost of work being performed.						
Corrective Action: Costs not spent against emergent issues now will be burned down over subsequent months. The T/CAM will work with the Project Controls Specialist to understand and resolve cost over-estimation issues.						
1.02C.06.00 Management, Leadership & Other Costs	**3,377**	**3,377**	**3,493**	**0**	**-117**	**4,256**
Explanation: This WBS element represents LOE work. As LOE work is minimal/predictable, cost variance here means some non-LOE must have been miscoded as LOE while invoicing.						
Corrective Action: Invoices will be examined, and coding errors located. Invoices more carefully reviewed going forward to avoid similar miscodes in the future.						
1.02C.06.02 Data Access Services	**5,377**	**4,893**	**5,163**	**-484**	**-269**	**6,872**
Explanation: Variances on this WBS are somewhat recovered from the previous month, due to completion of several packages that were contingent on small bits of remaining work. Remaining variances are due to several packages running late / behind schedule (principally Qserv Ingest, Qserv Monitoring Dashboard, Data Synth, and documentation). These packages are the focus of current development efforts and further recovery is expected.						
Corrective Action: Continue to monitor Jira carefully for any further "missed starts". Focus effort on packages running behind schedule and carefully control scope of implementation work. Continue to work to improve basis of estimation.						

1.02C.06.03 Task Framework	**140**	**140**	**0**	**0**	**140**	**1,119**
Explanation: This positive cost variance under this account is due to the invoice errors mentioned under the management account. This positive variance offsets the negative cost variance in WBS 1.02C.06.00. Work was accomplished under this WBS, but the actuals costs were not charged to this account.						
Corrective Action: We are working on correcting the invoice to move the actual costs from the management account to this account.						
1.02C.07.00 Processing Control and Site Infrastructure Management Engineering and Integration	**3,664**	**3,664**	**3,484**	**0**	**181**	**3,664**
Explanation: We believe that the cost variance is due to difference in past planning cycle budget being set higher because of escalation rates that automatically inflate budgeted costs, which was greater than our actual costs that would be charged.						
Corrective Action: no corrective action. This control account is now closed with a cost variance of $181k.						
1.02C.07.01 Processing Control	**1,503**	**1,503**	**1,355**	**0**	**148**	**1,503**
Explanation: We believe that the cost variance is due to difference in past planning cycle budget being set higher because of escalation rates that automatically inflate budgeted costs, which was greater than our actual costs that would be charged.						
Corrective Action: No corrective action. This control account is now closed with a cost variance of $148k.						
1.02C.07.04 Site Infrastructure	**4,216**	**4,216**	**4,386**	**0**	**-170**	**4,216**
Explanation: The outstanding epic to reorganize file systems and this control account can now be closed.						
Corrective Action: No corrective action. This control account is now closed with a cost variance of -$170k.						
1.02C.07.08 LDF Service Software	**1,717**	**1,509**	**1,618**	**-208**	**-109**	**3,811**
Explanation: The schedule and cost variances are due to delays in tasks with dependencies on and interactions with other Data Management teams and LSST subsystems. The primary activities impacting both schedule and cost are AuxTel testing and integration, and dependencies on Gen3 middleware for Batch Production and Data Backbone Services. The cost variance is also impacted by additional unscheduled work needed to support these activities beyond the expected completion dates.						
Corrective Action: We are closely tracking developments in these areas, providing support and making progress where possible. We are prepared to complete the necessary work once external subsystem dependencies are met during the remainder of calendar year 2019.						
1.02C.07.09 ITC and Facilities	**3,834**	**3,725**	**3,720**	**-109**	**5**	**21,524**

Explanation: The schedule variances is primarily driven by two things. The delay in the readiness of the Base Data Center and work that has been scoped for improvements at the LDF taking additional effort than initially anticipated.						
Corrective Action: The portion of the schedule variance driven by the delay in the Base Data Center mostly has been moved to reflect the new schedule, the portion that is affecting the variance we have decreased the urgency of its completion. Initial planned completion date was end of May we have relaxed that to middle of June due to the slack in the schedule, in doing this we have also avoided increase in staffing to meet the earlier deadline. The work for improvements at the LDF is being monitored to ensure that it remains in scope of the epic.						
1.02C.08.00 International Communications and Base Site Management Engineering and Integration	**523**	**523**	**888**	**0**	**-365**	**653**
Explanation: Negative cost variance in 1.02C.08.00 is due to higher than anticipated labor costs associated with supporting on boarding, training, and labor in setting up Information Technology (IT) team in La Serena, which has grown to 5 staff. In addition, the repatriation relocation to Canada of the former team lead, Ron Lambert, created the need for distributing some of his responsibilities to other staff in La Serena and requiring them to charge to this account. The original plan had only budgeted for the TCAM, but other team members are also charging this account for these items.						
Corrective Action: The budget for this work package will need to be supplemented with an LCR.						
1.02C.08.01 Base Center	**999**	**872**	**877**	**-127**	**-5**	**1,641**
Explanation: The negative schedule variance in 1.02C.08.01 is due to delays in the construction of the Summit and Base Facilities, and the corresponding delay in access to the Base Data Center for this work. It is currently anticipated that the Base Data Center full occupancy with stable power, cooling, and access control will not occur until end of May 2019. The positive cost variance in 1.02C.08.01 is due to partitioning of Base LAN into multiple annual acquisitions. Instead of procuring all the years at one time, there will be an FY19 - FY20 acquisitions for part of the LAN equipment.						
Corrective Action: Submit LCR to move remaining purchases to FY20 and FY21. LCR will be submitted in September 2019.						
1.02C.08.03 Long-Haul Networks	**22,878**	**22,430**	**22,290**	**-447**	**140**	**28,194**
Explanation: The key driver of this negative schedule variance is late completion on La Serena to Santiago with live traffic and uptime over LSST Lambda Ready attributing -300K to the schedule variance. Another large contributor to the SV is FIU-CIARA Management Contract Delivery #4 at -80k of the schedule variance. Both negative variances have been masked by the large positive schedule variance outlined in LCR-1824. Since LCR-1824 has been implemented we are able to expose the smaller negative schedule variances.						
Corrective Action: The LS - SCL $300k is due to the Summit and Base and ATS delays, The link in place but we have not exercised it with LSST traffic. We have exercised the LS - SCL AURA link with LSST, CTIO, and Gemini						

traffic which goes over the same fibers but and DWDM boxes (different ports). Because of this we will make this complete from the REUNA side in next month's report.						
1.04C.01.02 Summit Office	**3,649**	**3,658**	**3,870**	**9**	**-211**	**8,458**
Explanation: In WBS 1.04C.01.02, Summit Office, the negative cost variance (CV) of $211,264 is down 13% from last month. This CV in part reflects additional costs of meals for vendor personnel at the Pachón dining facility, which has now gone down somewhat as the Coating Plant (VA) team has departed. The CV also reflects increased technical support for temporary hired electricians as well as other operational expenses (fuel, water, and power) being higher than expected.						
Corrective Action: This CV will continue to be monitored. The downward trend is expected to continue as the quantity of vendor meals will be lower for the next several months. The cost of electrical power is also expected to go down, as a project to convert from generator power to less expensive commercial electricity for the dining facility and other support facilities has been recently implemented.						
1.04C.03.01 Summit Construction Management	**2,279**	**2,269**	**2,500**	**-9**	**-230**	**2,279**
Explanation: In WBS 1.04C.03.01, Summit Construction Management, the negative Cost Variance (CV) of $230,459 is up 4% from last month. This CV, and its gradual increase, is due the extension of the Summit Facility construction project and related costs for a longer period than had been planned and budgeted.						
Corrective Action: Management of the Pflow lift contract is the lone remaining activity requiring Summit Construction administration. That contract is now substantially complete expected to be closed. The application of contingency will be recommended to offset the final CV in in this account.						
1.04C.03.03 Summit Support Facility	**30,157**	**30,157**	**30,301**	**0**	**-144**	**30,157**
Explanation: The remaining cost variance is due to costs in excess of the original plan for the PFLOW contract.						
Corrective Action: No corrective action. This control account is now closed with a cost variance of -$144k.						
1.04C.03.04 Summit Lodging and Dining	**535**	**470**	**239**	**-65**	**231**	**535**
Explanation: In WBS 1.04C.03.04, Summit Lodging Addition, the positive Cost Variance (CV) of $231,335 is down 15% from the last reporting period. While this is generally an improvement, the overall CV continues - in part due to a lag between payments made to the contractor Proyect and their CASNET posting, and also due to invoicing by the contractor being less than the advance reported in the monthly status. Some of that lower reporting of progress stems from delays caused by additional required foundation and substructure work.						
Corrective Action: This CV is well understood and does not present a major concern, as the work pace is now accelerating which should result in billings to offset the +CV. These billings will include a change order for the additional foundation costs, and other advance as the walls and interior of the addition are constructed. The project is now expected to be complete by the end of August, which is still timely for the use of the Hotel addition for LSST vendors, notably the TMA team arriving in September.						

1.04C.04.01 Dome System Management	**939**	**939**	**1,063**	**0**	**-124**	**939**
Explanation: In WBS 1.04C.04.01, Dome System Management, the negative cost variance of $123,603 is up slightly from the last reporting period due to incremental increase in management labor cost charged to this account. EIE contract oversight remains a high priority and the Telescope and Site management team which results in more time and travel being charged to support this enhanced effort.						
Corrective Action: This account and its CV will be monitored. At an appropriate point it is expected to be closed, with subsequent Dome management labor being charged to an AIV account.						
1.04C.04.02 Dome Fabrication Contract	**15,312**	**14,906**	**15,885**	**-406**	**-979**	**16,184**
Explanation: In WBS 1.04C.04.01 Dome Fabrication Contract the Schedule Variance (SV) of =$406 improved from last month as value was earned for LCR-1707 and LCR-1708. The negative schedule variance is still reflecting the continuing and increasing lateness in the delivery of the Dome to the site and its on-site erection. The Cost Variance (CV) of -$979 improved from the last report as value was earned but previously paid for the two LCRs mentioned above. Contributing to the overall CV are the costs for on-site erection vendors – crane (SIMAQ), erection labor (MILL) and surveyor – being borne directly by LSST to help accelerate the work.						
Corrective Action: The SV and CV in this contract are being addressed in a comprehensive recovery plan, which includes the direct management and contracting of key on-site work accompanied by rigorous technical and managerial oversight by the Telescope and Site team. EIE is required to submit monthly schedule updates for ongoing work and shipments that are reviewed by the technical management team and project controls. LCRs have also been implemented providing contingency to cover cost impacts due to revised requirements, which also facilitates EIE's ability to make payments to their vendors in Europe and Chile.						
1.04C.04.03 Calibration Screen Fabrication	**256**	**339**	**595**	**82**	**-256**	**605**
Explanation: Although progress was made on the calibration screen, the negative cost variance increased from 229k to 256k due to LCR-1581 being implemented that included $26.9k of additional work to provide panel spares and increase the rotational accuracy. Following the recovery plan for the Dome and calibration screen contracts that was implemented in January, which results in us paying for the work prior to completion, this cost was added to the previously accumulated cost variance. No further LCRs are anticipated and the variance is expected to erode as the work is completed.						
Corrective Action: As stated in the above explanation and previous variance narratives, the cost variance which has been incurred due to the recovery plan set in place in January for the Dome and Calibration screen contracts, continues to erode as work is performed, therefore no further corrective action is necessary.						
1.04C.05.01 Mount System Management	**1,223**	**1,223**	**1,344**	**0**	**-122**	**1,223**
Explanation: KLM40501A.TMS: During the factory acceptance we required additional LSST resources for the review. This was not budgeted. The account is closed No additional charge to this account are expected.						
Corrective Action: No corrective action. This control account is now closed with a cost variance of -$122k.						

1.04C.06.01 Mirror System Team Management	**555**	**555**	**660**	**0**	**-106**	**555**
Explanation: In WBS 1.04C.06.01 Mirror System Team Management, the negative cost variance (CV) of $105,508 is the same as reported last month. This is due to additional management effort that was required for the M1M3 and M2 systems. Both are now successfully delivered to Chile.						
Corrective Action: No corrective action. This control account is now closed with a cost variance of -$106k.						
1.04C.06.03 M1M3 Cell	**13,359**	**13,083**	**14,151**	**-276**	**-1,069**	**13,374**
Explanation: The negative $276k SV has improved from $376k last. A lot of this improvement come from closing out the M1M3 surrogate work at CAID. The M1M3 labor team continues to close out late thermal work bringing the labor component of the schedule variance to -$242k. The 1.1M cost variance is mainly driven by additional work performed by the mirror lab and CAID. This work was in our estimate to complete but wasn't implemented in the baseline via an LCR because of the departure of the previous CAM.						
Corrective Action: We will implement an LCR soon to correct the to go budget for the M1M3 SOML testing effort and CAID M1M3 integration and test activities. The team continues to work hard on outstanding M1M3 activities that are driving this schedule variance and are confident that this effort will be completed without impacting downstream activities.						
1.04C.06.04 Secondary Mirror M2 Contract	**13,941**	**13,941**	**14,192**	**0**	**-251**	**13,941**
Explanation: The negative CV of $251k represents underestimating LSST labor charges supporting the M2 contract. While this account was requested to be closed in Sept 2018 charges appeared this month as a result of an error in the HR department. Project controls is working with HR and accounting to reverse these charges and keep closed accounts closed.						
Corrective Action: This account is closed. We are working on correcting the May charges to bring the CV back to -$239k as reported last month.						
1.04C.09.01 Coating System Mgmt & Engineering	**760**	**760**	**891**	**0**	**-131**	**760**
Explanation: In WBS 1.04C.06.01 Coating System Management and Engineering, the negative cost variance of $131,118 CV has increased slightly from last month. This CV results from higher than expected labor and travel expenses in support of the coating system.						
Corrective Action: No corrective action. This control account is now closed with a cost variance of -$131k.						
1.04C.10.01 OCS System Mgmt and Engineering	**1,683**	**1,683**	**1,801**	**0**	**-118**	**1,683**
Explanation: The negative cost variance of -$118k is due to sick leave being accrued on the old management. these charges should have been redirected to the new management account 1.04C.15.01						

Corrective Action: No corrective action. This control account is now closed with a cost variance of -$118k.						
1.04C.10.07 OCS Monitor	**119**	**119**	**308**	**0**	**-189**	**119**
Explanation: The negative cost variance of -$189k is due to INRIA charges being recorded under the old account instead of 1.04C.15.07. This negative entry is offset by a positive CV under 1.04C.15.07 where the work is budgeted.						
Corrective Action: No corrective action. This control account is now closed with a cost variance of -$189k.						
1.04C.12.02 Safety Systems	**797**	**654**	**576**	**-144**	**78**	**797**
Explanation: KLM41202A.PROC: The SV of 143,511 is from the installation of the Global interlock system (GIS) being delayed by the delay in the TMA shipping. These installations will be performed by Tekniker. All hardware has been procured and tested and will be reviewed at Tekiniker on June 6.						
Corrective Action: We will have a workshop in September to see if we can begin earlier integration of the GIS system on the summit without having all the other subsystems interlocks systems (dome, hexapod, rotator...) ready.						
1.04C.12.05 Summit Network System	**1,047**	**992**	**1,407**	**-55**	**-415**	**1,160**
Explanation: The negative cost variance in 1.04C.12.5: Due to delays in the summit facility construction schedule and late information from Telescope subsystem vendors regarding network connectivity, extra labor has been expended, and activities that were scheduled serially in the baseline are now being done in parallel to recover schedule. Staff that were planned 50% on 1.04C.12.5 and 50% on KLM20803 have been primarily on the former.						
Corrective Action: Cost variance is unrecoverable if we are to deliver without impacting project critical path. Continue schedule recovery activities through FY19. An IT Infrastructure Engineer was hired, with the start date of 3/1/19. Three temporary electrical engineers were hired to perform work installing conduits, cable trays, and cables. In addition, the high load of coordinating activities across Summit Facility (computer room and 5 floors), auxiliary telescope, auxiliary instruments, and Base Facility (computer room, offices and common areas) will require hiring a full-time IT manager in La Serena. Also, due to the need to keep Summit and Base networks operating to an implied SLA, we need additional system/service support while we build out the rest of the observatory, and we are enlisting IT resources in Tucson to assist more in this. We are aligning the replacement and job requisitions and descriptions to reflect this division of responsibilities.						
1.04C.12.06 Tools and Equipment	**1,574**	**1,525**	**1,327**	**-48**	**198**	**1,574**
Explanation: The $198K positive cost variance comes from the accomplishment of milestones achieved before being invoiced by CAID ($50K) and for equipment procurement received ($150K)						
Corrective Action: no corrective action required. We elected not to use an estimated actual to keep visibility on these pending invoices.						

1.04C.12.07 Vehicles and Transportation	**502**	**387**	**361**	**-116**	**25**	**502**
Explanation: The negative schedule variance of $116K is the consequence of reduced fuel and maintenance needed than planned in the baseline. This activity is essentially being status earned as spent.						
Corrective Action: no corrective action needed						
1.04C.12.08 Shipping and Logistics	**1,471**	**1,952**	**2,377**	**481**	**-426**	**2,481**
Explanation: The positive schedule variance of $480K is due to the early payment of the M1M3 mirror shipment ($770K). The $426K negative cost variance is due to overspending for previous shipments.						
Corrective Action: Contingency fund will be added to this account. Additional costs for TMA and M1M3 shipments are in the ETC.						
1.04C.12.10 M2 Equipment	**134**	**18**	**54**	**-117**	**-36**	**134**
Explanation: The negative schedule variance of $117K is a result of delayed activities for the M2 baffle by lack of resources in Tucson.						
Corrective Action: Resource limitations are being corrected to address the M2 baffle activities. The machine shop is progressing on M2 baffle design and manufacturing activities and we are forecasting a Feb 2020 completion for M2 Baffle with 100 days of float.						
1.04C.12.13 Coating Optical Equipment	**180**	**180**	**22**	**0**	**158**	**180**
Explanation: This is the payment for the Spectrophotometer. This instrument is on site right now. The payment has been approved and the instrument accepted.						
Corrective Action: No corrective action. The payment has been made, and the instrument approved on site.						
1.04C.12.17 Post Construction	**372**	**213**	**191**	**-159**	**22**	**472**
Explanation: In WBS 1.04C.12.17, Summit Facility Post Construction the negative schedule variance (SV) of $158,618, has increased from last month above the threshold requiring a reporting narrative. This primarily represents an increasing delay in the advance of roadwork and in build-out of the Camera areas.						
Corrective Action: The main corrective action for this SV will be to accelerate, to the extent possible, the roadwork which has been hampered by winter weather, and to initiate the second phase of Camera area work as soon as possible, construction and outfitting of the Maintenance Refrigeration Compressor Room.						
1.04C.12.18 Environmental Awareness System	**158**	**30**	**9**	**-127**	**21**	**277**
Explanation: Still approximately 3 months behind schedule due to previous unplanned shifting of resources to higher priority subsystems. HVAC contract is now processed and waiting to be executed.						

Corrective Action: Have identified contractor to fab custom components. Plan to prioritize finishing design work to proceed with this.						
1.04C.13.03 Base Construction Management	**349**	**349**	**487**	**0**	**-138**	**565**
Explanation: In WBS 1.04C.13.03, Base Facility Construction Management, the negative cost variance (CV) of $137,560 is down 7% from last month. This continues a downward trend which is due to less inspection and management time being billed to this account. The cause of the overall CV is the longer-than-budgeted duration of the Base Facility Construction due to change orders during Phase 1 remodeling and delays in the new building construction.						
Corrective Action: To continue to mitigate and reduce this CV, conclusion of the project is being expedited as quickly as possible. The new building construction is expected to be complete by the end of June, slipping approximately 2 weeks since the last report. Following that, the final Phase of the remodeling will commence. This final remodeling work is expected to require less management oversight.						
1.04C.13.04 Base Site Preparation	**1,696**	**1,506**	**2,121**	**-189**	**-614**	**1,696**
Explanation: In WBS 1.04C.13.04, Base Facility Site Prep and Remodeling (Phase 1), the negative schedule variance (SV) of $189,220 is unchanged from the last report. The remodeling project continues on hold. Stage 5 remodeling of the existing computer rooms to create meeting rooms, will start once the computing equipment is relocated to the new Data Center. The Cost Variance (CV) of $544,163 is also the same as in the last report. This CV reflects the LSST share of change orders and project support costs incurred during the remodeling work to date.						
Corrective Action: No corrective action is required for the SV or CV at this time. The schedule will be revised to allow appropriate tracking when the Stage 5 remodeling project is started in August. To address the CV, application of contingency will be considered once the final accounting of change orders is available. The total increase assigned to LSST, is expected to be less than the current CV, as the LSST share of the remodeling work is lower than the amount being applied during construction to simplify accounting of the partner shares.						
1.04C.13.05 La Serena Base Facility Construction	**6,739**	**6,673**	**7,621**	**-66**	**-948**	**6,739**
Explanation: In WBS 1.04C.13.05, Phase 2 Base Facility Construction, the negative Cost Variance (CV) of $948,119 is up 24% from the last reporting. This CV and its increase are due to 2 factors. Chilean based management labor is being billed to this construction account via the partner-share account, an expense which was not originally budgeted here. The second and more significant factor is the billing for change orders accumulated over the course of the construction, which have not as yet been covered by contingency application.						
Corrective Action: The corrective action is expected to be a request for contingency to cover the increase, to be applied once the contract is complete allowing a final accounting of the LSST share of the increase. It should be possible to initiate this accounting action during the next reporting period.						
1.04C.14.02 Integration Tooling and	**1,827**	**1,523**	**1,697**	**-304**	**-173**	**2,082**

Equipment						
Explanation: The negative schedule variance of $304K is the result of delays for ComCam ($141K), for Image Quality Diagnostics ($110k) and for the laser tracker interface phase 2 ($45K). The negative cost variance of $173k is mainly a consequence of overspending labor for ComCam ($151K).						
Corrective Action: The schedule variance will be mitigated with SHWFS and Comcam progress. Overspending will be corrected by allocating contingency funds						
1.04C.14.03 Major Equipment Leasing and Rental	**281**	**390**	**505**	**109**	**-116**	**649**
Explanation: The positive schedule variance of $109K is the consequence of earlier than planned acquisition of rental equipment for the dome construction. The $116K negative cost variance is due to higher expenses than baselined.						
Corrective Action: LCR was submitted to request more budget for crane and scaffolding rental.						
1.04C.14.04 Subsystem Integration and Test	**1,466**	**532**	**921**	**-934**	**-389**	**4,514**
Explanation: The negative $934K schedule variance is a combination of delayed labor expenses for (TMA $117K), M1M3 coating preparation ($361K), dome construction ($128k), coating plant ($68k), software deployment activities ($127K), camera rooms preparation ($90k) and TMA ($81K). The negative cost variance of $389K is mainly due to a labor cost of $113K for TMA oversight and expenses for the coating chamber ($89K).						
Corrective Action: The variances will be reduced as the summit work progresses with the coating plant, the camera rooms and the M1M3 activities.						
1.04C.15.01 Telescope and Site Software Management	**210**	**210**	**23**	**0**	**187**	**514**
Explanation: The large positive cost variance under 1.04C.15.01 is due to the Labor Recharge (Vacation and sick balances). when home account of KLM41501A is charging out to another account. This is a relatively new account and once the team begins taking holiday/vacation those charges will accrue under 1.04C.15.01; reducing the positive cost variance.						
Corrective Action: None. The positive variance will naturally decrease as vacation and sick time is used.						
1.05C.01.01 System Management	**1,991**	**1,991**	**1,888**	**0**	**103**	**3,334**
Explanation: The positive cost variance continues its downward trend, decreasing from $109K last month to $103K this month, as anticipated due to a change request with improved labor rates that was implemented in the March 2019 baseline.						
Corrective Action: No further action is needed, and the cost variance is expected to decrease below the threshold in coming months.						

1.06C.01.02 Simulation & Analytic Tools Management	**2,738**	**2,739**	**2,599**	**0**	**139**	**2,739**
Explanation: The positive cost variance of $139K continues to improve, decreasing from $143K last month, as the contract with Purdue University is closed out (KLM60102C).						
Corrective Action: No corrective action is needed as invoices from Intercax for software customization should be received over the next few months which will further reduce the variance in this charge account.						
1.06C.02.02 Commissioning Planning, Preparation, Tooling, & Simulations	**1,371**	**1,350**	**925**	**-20**	**425**	**2,402**
Explanation: The $425K positive cost variance has increased from $367K in March. The primary issue is a delay in hiring commissioning support scientists with the positive cost variance increasing $40K from April in KLM60202A.LABOR.						
Corrective Action: A change request submittal is in progress which will include improved labor cost estimates. The hiring campaign for a support scientist position will conclude before the end of FY19.						

4.7 Obligations as of 31 May 2019

Vendor	Description	Amount
Aerotek Professional Services, Inc.	LSST Staffing contracts	$131,147
Amazon Web Services	Cloud resources for web hosting and prototyping	$22,956
Astelco Systems GmhB	Differential Image Motion Monitor (DIMM)	$186,760
Aston Carter	Information Technology and Communications (ITC) Contracted Services	$82,036
Astronomical Consultants & Equipment, Inc.	Auxiliary Telescope and Dome Refurbishment	$20,182
AURA	Base Site Preparation	$621,571
BBC Chartering USA, LLC	Coating Chamber and TMA Freight	$94,850
BellDex	Belldex IT Support	$39,080
Caltech	DM Science User interface and Analysis Services FY19	$3,301,025
Centre National de la Recherche Scientifique	IN2P3	$80,698
D4D Consulting Ltd.	DM Calibration support	$49,833
Dell Marketing L.P.	T & S Computing Hardware	$69,460
Facilities Engineering	Vacuum Lifting Pads	$77,868
Florida International University	Network Provider for US Chile link	$139,026
Harvard University	Atmospheric Calibration Support	$58,035
Hislop, Richard	Safety Support	$26,700
Hoes, Charles	Safety Support	$30,296
IGUS Inc.	Optical Fiber Cables	$33,213
Imagine Optic	hack-Hartmann Wavefront Sensor System	$112,618
INRIA	INRIA OCS User Interfaces	$56,645
Intercax	Syndeia MagicDraw to JIRA plugin	$45,000
JDP Metrology Consulting, LLC.	Laser Tracker Metrology Consulting	$42,000
Kimball International, Inc	Tucson Office Space Renovations	$22,543

Kuehne & Nagel	Global container logistics	$409,743
Longhorn Industries	Project Controls Consulting	$656,809
Marsh USA	“all risk” transportation insurance	$300,000
New River Kinematics	Spatial Analyzer	$58,750
Observatory Sciences Ltd.	Pointing Component	$219,360
Office of Finance and Treasury	Data Management MREFC Agreement for Princeton University	$4,417,603
Optical Data Associates, LLC	ComCam Optics Contract	$29,364
Phase Motion Control S.p.A	Dome Phase Motion Control System	$254,893
Rector, Travis	LSST EPO education and media advisor	$27,000
Regents of the Univ of CA	UC Davis LSST Support Contract	$288,171
Sozen, Inc.	FY19 deblending work for DM	$109,500
Stanford University	Science Data Archive and Application Services	$3,994,530
Union Temporal de Empressas LSST TMA	LSST Telescope Mount Assembly Design and Fabrication	$3,822,775
University of Arizona	UoA Richard F. Caris Mirror Lab	$527,453
University of Florida	FY19 DM Network Support	$72,024
University of Illinois	NCSA MREFC Subaward	$13,236,778
University of Pittsburgh	Support to Science Quality and Reliability Engineering	$29,979
University of Washington	LSST System Scientist and DM Alert Production Services	$6,319,264
VON ARDENNE GMbH	LSST Coating Plant Contract	$2,096,130
Miscellaneous 1	$10K < X < $20K	$571,278
Miscellaneous 2	<$10K	$986,824
LSST US Subtotal		**$43,771,768**
A&C INGENIERIA LIMITADA	LSST / Scaffold support - general contract	$57,997
ANA MARIA ZAVALA TAPIA	LSST Casino contract	$35,504
ARCADIS CHILE S.P.A.	Light Removal for M1M3 mirror transportation to the summit	$36,995
Cranes Rental	Large Cranes Rental for TMA construction	$1,016,997
CALLEGARI E HIJOS LTDA.	Mechanical Contractor support	$26,544
Empresa Nacional de Energia Enex S. A.	Petrol for LSST Summit Facilities	$66,218
Enter Comunicaciones Spa	AURA network Fiber repair	$77,355
FUNDACION INRIA CHILE	LSST Operator Visualization Environment LOVE	$214,417
IMOPAC LTDA	LSST Improvement of Access Roads	$98,903
ING. DE TRANSP. JAVIER CORTES SOC. LTDA.	LSST Improvement of Access Roads	$553,502
JACQUES SEBAG,	Removal of Road Obstacles for LSST Coating Chamber Transportation	$59,568
MAESTRANZA FAREMIN LTDA.	Dome roof - 2 node pieces fabrication	$44,260
MILL MONTAJES INDUSTRIALES LLANQUITRUF LIMITADA	Steel erection crew construction of LSST Dome	$73,079
PINO Y LABARCA LIMITADA	Lease and maintenance of Chemical toilets	$30,110
PREMIUM INGENIEROS SPA	Piping for Coating dedicate Chiller	$35,509
PROYECT CONSTRUCTORA E INMOBILIARIA LTDA.	Piping for Coating dedicate Chiller	$194,493
RED UNIVERSITARIA NACIONAL	REUNA	$1,405,360
Miscellaneous 1	$10K < X < $20K	$180,394
Miscellaneous 2	<$10K	$326,690
Chilean Subtotal (Estimated)		**$4,533,897**
Total		**$48,305,665**

5 Risk Management

5.1 Brief Narrative

The Risk and Opportunity (R&O) board is now focusing on schedule-based reviews for risks with upcoming trigger dates and/or upcoming mitigating actions anticipated to complete. The JIRA tool now enables focus on discrete mitigating actions, an estimate of how these actions will reduce current exposure levels, and capturing anticipated completion dates of these mitigating actions. In addition, the project now has the ability to report the expected post-mitigations PWCE. With this new PWCE after mitigation functionality, the R&O board focused on entering anticipated completion dates and the expected risk reduction on mitigating actions.

The R&O register contains 176 active risks and 12 active opportunities. The overall probability weighted cost exposure (PWCE) decreased from $34.46 million to $33.89 million. The overall PWCE after mitigations decreased from $31.85 million to $29.40 million.

There were 18 project controls LCRs implemented; 12 had an impact on cost or schedule, resulting in a net contingency draw of $1,199,416. As of the end of the month, the Project has allocated 65% of the total contingency to the baseline through the change control process. The remaining contingency of $28.4 million is 22% of ETCI (ETCI=BAC-BCWP) and 21% of ETCII (monthly bottom up).

There was no change in the baseline finish date leaving six months of contingency between early and late finish. The schedule issues and forecast dates detailed in Section 3 above point to an increasing schedule risk exposure, but the Project is actively addressing mitigations.

There were no changes in the technical requirements or performance predictions. Technical margins remain unchanged, and 32 scope options, as listed in the LSST Scope Options document (LPM-72), remain available at an estimated value of $27.2 million.

Together, the cost, schedule and scope contingency indicate the Project will be completed within budget and on schedule.

5.2 Liens on Budget Contingency

The table below is the Project Manager's Lien List used to assess the project's contingency status. The table summarizes the processed and pending change requests and the cumulative cost variance from the earned value report. It also provides a forecast of potential contingency liens from the Risk and Opportunity register and a separate detailed list of items under careful watch by the Project Manager.

Project Manager Lien List May 2019

Lien ID	Description	Value ($)	Contingency Balance ($)
N/A	Initial Agreed Contingency	$82,392,999	$82,392,999
L1	Processed Change Requests	($53,966,641)	$28,426,358
L2	Cumulative Cost Variance	($7,426,711)	$20,999,647
L3	Pending LCR Estimates	($3,201,435)	$17,798,212
L6	Cost of Schedule Contingency (reserve for team labor)	$0	$17,798,212
L7	Project Manager Watch List Subtotal	$0	$17,798,212
L8	BCWR - EACII	($2,026,030)	$15,772,182

The following LCRs have entered the “Implemented” or “Pending” state and have been removed from L8 this month.

LCR #	Description	Amount
LCR-1786	Increase Dome Scaffolding Budget	-$100,000
LCR-1808	Additional Budget for Dome Construction Crane	-$180,000
LCR-1708	Dome Facility ICD and Louver Impact	-$725,390
LCR-1707	Dome Stairs and Walkways CR	-$276,143
	Total	**-$1,281,533**

The following two tables contain the top risks and opportunities as evaluated by the R&0 register PWCE. The Opportunities table contains the top 10 items; the Risk table includes the top 10 items plus the critical risks from the 5x5 matrix, even if they are not in the top 10. The top risks are tracked closely as they are considered to have the largest potential contingency impact. Note that the risk IDs have changed with the new R&O tool. The mapping of ID numbers from the old system to the new system is available on the LSST R&O website.

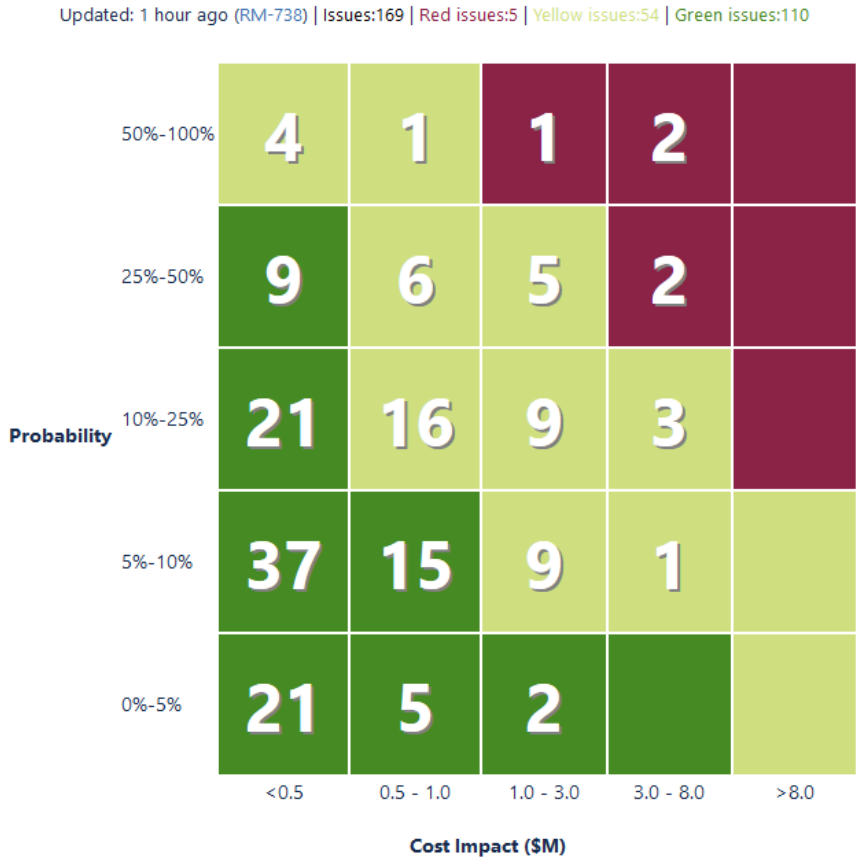
Top Risks List

Sort #	Risk ID #	Subsystem	WBS	Risk Title	Probability Weighted Cost Exposure ($k)
1	RM-886	Project Management Office	01C	Subsystem Milestone Execution	4,347
2	RM-888	Project Management Office	01C	Multi-agency coordination - Camera Delivery	2,268
3	RM-773	Data Management	02C.04	Computing power required for Data Release Production exceeds estimates by large factor	1,348
4	RM-817	Telescope & Site	4.5	Mount Late Delivery	1,332
5	RM-887	Project Management Office	01C	Institutional Overhead Rates	1,260
6	RM-814	Telescope & Site	4.4	Dome Late Delivery	1,221
7	RM-775	Data Management	02C.04.06	Unanticipated characteristics of real data result in poor MultiFit performance (computational)	962
8	RM-733	Systems Engineering	06C.02	Discontinuity between subsystem I&T and Commissioning staffing levels	888
9	RM-815	Telescope & Site	4.14	Telescope and Site Integration activities underestimated	851

10	RM-723	Data Management	02C.04	Object counts exceed expectations, leading to insufficient compute	823
Date: 6/6/2019				***Top Ten Total:***	**15,300**

Top 10 List - Opportunities					
Sort #	**Opp ID #**	**Subsystem**	**WBS**	**Title**	**Probability Weighted Cost Exposure ($k)**
1	RM-628	Project Management Office	1.01C.01	Favorable Chilean Currency Exchange Rate Factor	1,480
2	RM-629	Project Management Office	1.01C	Favorable Personnel Costs	442
3	RM-630	Project Management Office	1.01C	Favorable Material Estimate Uncertainty	340
4	RM-785	Systems Engineering	1.06C.05	Commissioning Finishes Early	113
5	RM-631	Project Management Office	1.01C	Favorable Institutional Overhead Rates	60
6	RM-627	Data Management	02C.10	New or different technology provides saving in hardware/effort.	30
7	RM-786	Systems Engineering	1.06C	Standardizing Common Hardware Across Subsystems	30
8	RM-624	Data Management	02C.04.06	Exceptional MultiFit Performance	25
9	RM-787	Systems Engineering	1.06C.05	Camera Verification On Summit Finishes Early	23
10	RM-632	Project Management Office	1.01C	Purchase Forward Planned Hardware Sooner with Favorable Exchange Rates	3
Date: 6/6/2019				***Top Ten Total:***	**2,544**

The 5x5 probability vs. impact matrix below clearly shows the severity of the highest LSST Risks.



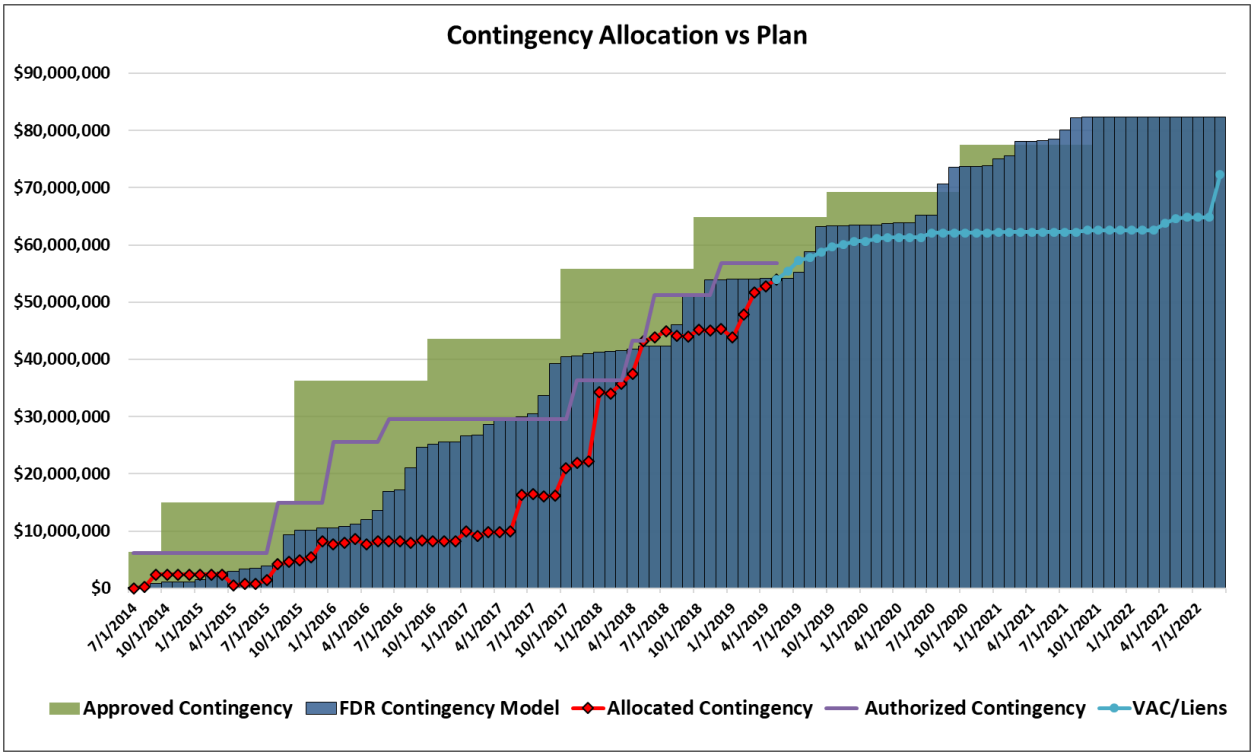
The risks in the critical range are described in the following table.

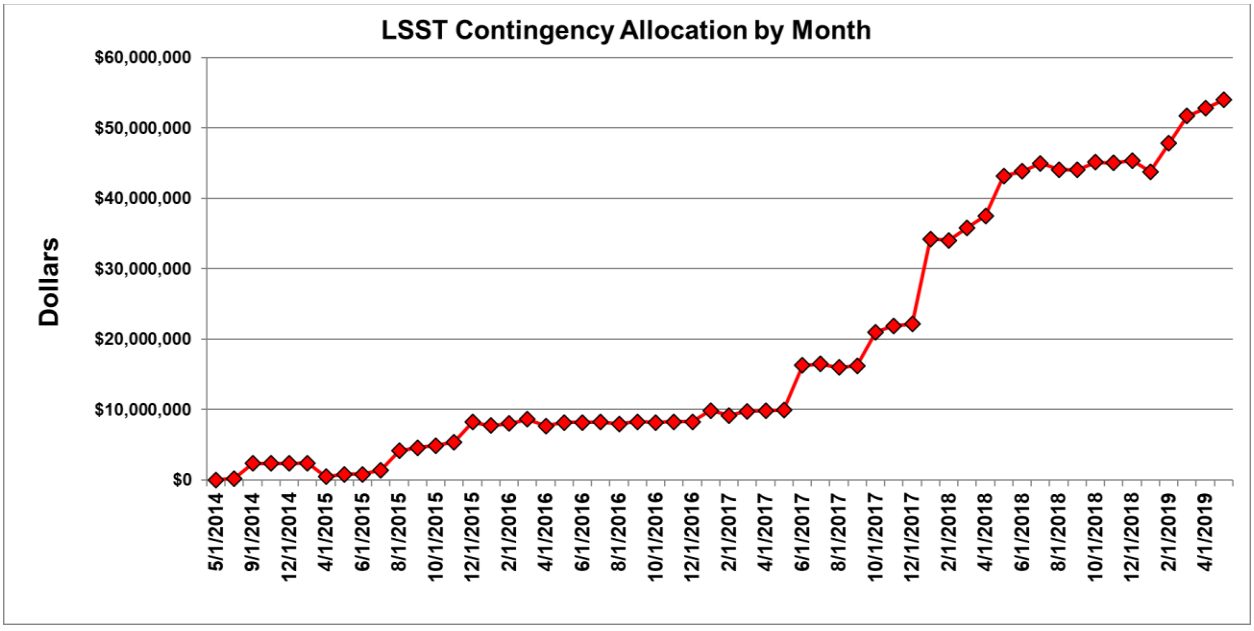
JIRA ID	Subsystem	WBS	Summary	PWE ($K)	Proposed Management Response
RM-886	Project Management Office	01C	Subsystem Milestone Execution	4347	Schedule and contingency will be used along with reworking the integrated plan to deal with subsystem delays
RM-888	Project Management Office	01C	Multi-agency coordination - Camera Delivery	2268	At this time the NSF and DOE efforts are on the critical path. ComCam reduces the direct dependency of late Camera delivery but with an 80% confidence of delivery within 5 months of due date this risk covers the residual impact of the camera being later that ComCam can stay efficient.
RM-817	Telescope & Site	4.5	Mount Late Delivery	1332	Working with vendor to develop logistics plan to minimize schedule

					risks in shipping. Oversight during the next few months as work focuses on factory integration to support testing campaign. Aug 2017: TMA is now 2 months late, with shipment in July 2018. Jan 2019: TMA is now scheduled to depart Spain in May 2019. Working with Dome and SE to improve parallel work flow.
RM-887	Project Management Office	01C	Institutional Overhead Rates	1260	AURA was chosen as the basis because very little can be done in response to a rate change. AURA centers, including NOAO are subject to NSF approval so changes are well understood and will come with significant advanced warning.
RM-814	Telescope & Site	4.4	Dome Late Delivery	1221	Dome vendor has maintained schedule as of September 2016. The dome vendor is now committed to working through the winter months rather than stop work completely in an attempt to minimize schedule. Embedded plate alignment is much longer than planned...final completion is now Oct 2018, which will interfere with TMA installation. Jan 2019 Update: working to support enclosed dome by May 2019, but need additional contingency funds to support new schedule and cash flow issues.

5.3 Budget Contingency Allocations

The first chart below plots the actual contingency usage (red line) against the "algorithmic" contingency model (blue bars) and the risk-based contingency annual amounts agreed with NSF (green background). The purple line tracks the total authorized contingency. The light blue plot represents the delta of the time phased remaining baselined work against the bottom up ETC and tries to establish when contingency will be needed to fund those items not currently in the BAC. The cumulative cost variance has been added to the plot to better reflect what is in the liens list and is represented in the last period of the project. The second chart below provides a more detailed view of the actual cumulative contingency allocated to the baseline budget.





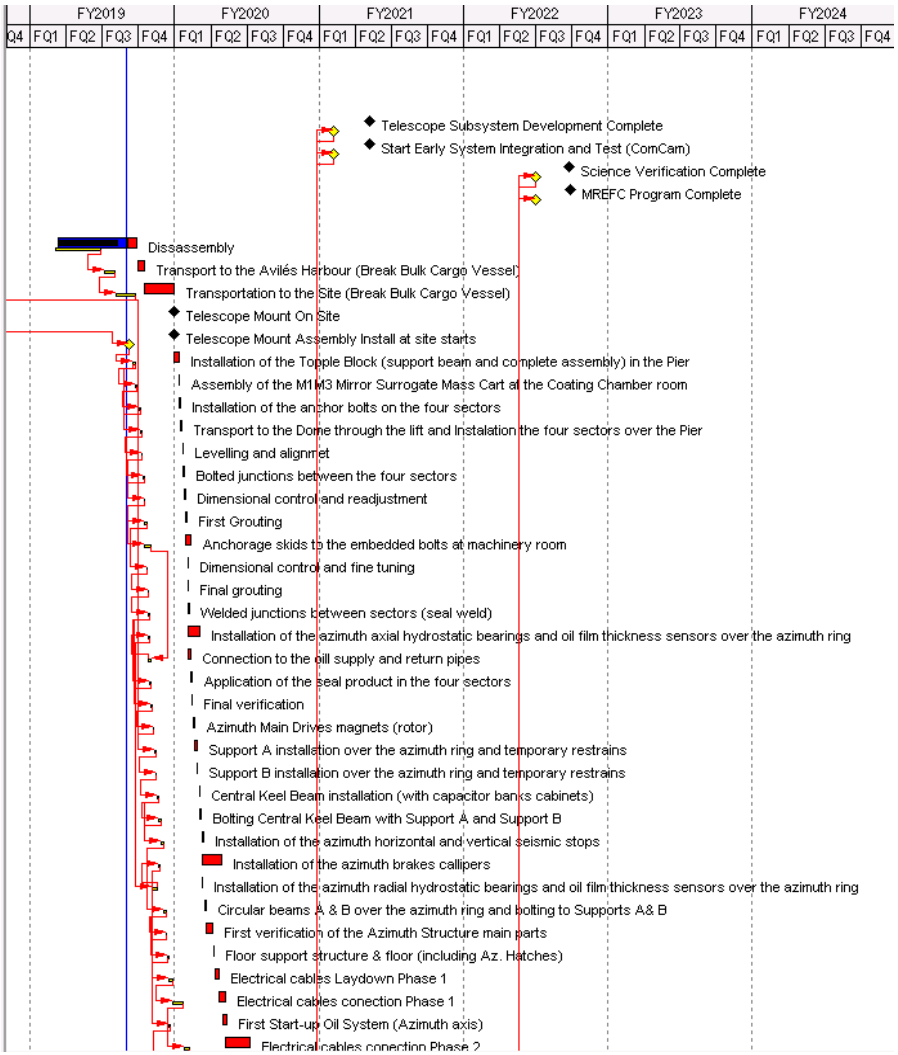
The table on the following pages identifies the LSST Change Control items approved during the period that had a cost or schedule impact. It lists each applicable LCR and includes the NSF approval date for those changes whose amount thresholds required prior agency authorization. In addition to this table of cost and schedule related LCRs, Section 7 provides a complete list of LCR activity for the reporting period.

Period: May 2019						Allocation		Running Totals		
Change Control ID	Description	NSF Approval Date	Risk ID	Affected WBS/Control Account	Schedule Impact	"Puts"	"Takes"	6 Month Jan - Jun 2019	Authorized Balance	Total Remaining Balance
Starting Contingency Balance								($7,391,118)	$4,099,190	$29,625,775
LCR-1787	Minor Update to Commissioning Plan/Budget		N/A	1.06C.02.02	None	$0	($0)	($7,391,118)	$4,099,189	$29,625,774
LCR-1793	Move up Calibration Screen EIE Milestone		N/A	1.04C.08.03	None	$0	($0)	($7,391,118)	$4,099,189	$29,625,774
LCR-1786	Increase Dome Scaffolding Budget		RM-814 RM-826 RM-94	1.04C.14.03	None	$0	($100,000)	($7,491,118)	$3,999,189	$29,525,774
LCR-1808	Additional Budget for Dome Construction Crane		RM-814	1.04C.04.02	None	$0	($180,000)	($7,671,118)	$3,819,189	$29,345,774
LCR-1754	NCSA FY19 Hardware Budget Reallocation from ComCam		RM-841	1.02C.07.09	None	$55,150	$0	($7,615,968)	$3,874,339	$29,400,924
LCR-1789	EPO Revised Staffing Plan		RM-892	1.05C	None	$31,117	$0	($7,584,851)	$3,905,456	$29,432,041
LCR-1803	Baseline Additional M1M3 Thermal Systems Effort		RM-825	1.04C.06.03	None	$0	($15,000)	($7,599,851)	$3,890,456	$29,417,041
LCR-1785	Auxiliary Telescope Summit Labor Epics		RM-871	1.04C.08.03	None	$0	($124,894)	($7,724,745)	$3,765,563	$29,292,148
LCR-1824	Move Up completed Long Haul Network Milestones		N/A	1.02C.08.03	None	$0	($0)	($7,724,745)	$3,765,563	$29,292,148
LCR-1823	Move 1.04C.15.07 End Date to August 2020		N/A	1.04C.15.07	None	$0	$0	($7,724,745)	$3,765,563	$29,292,148
LCR-1784	ComCam Fabrication and Shipping Update		RM-819	1.04C.14.02	None	$0	($10,222)	($7,734,967)	$3,755,340	$29,281,925
LCR-1825	NCSA May 2019 Schedule Update		N/A	1.02C.07.09	None	$0	($0)	($7,734,968)	$3,755,340	$29,281,925

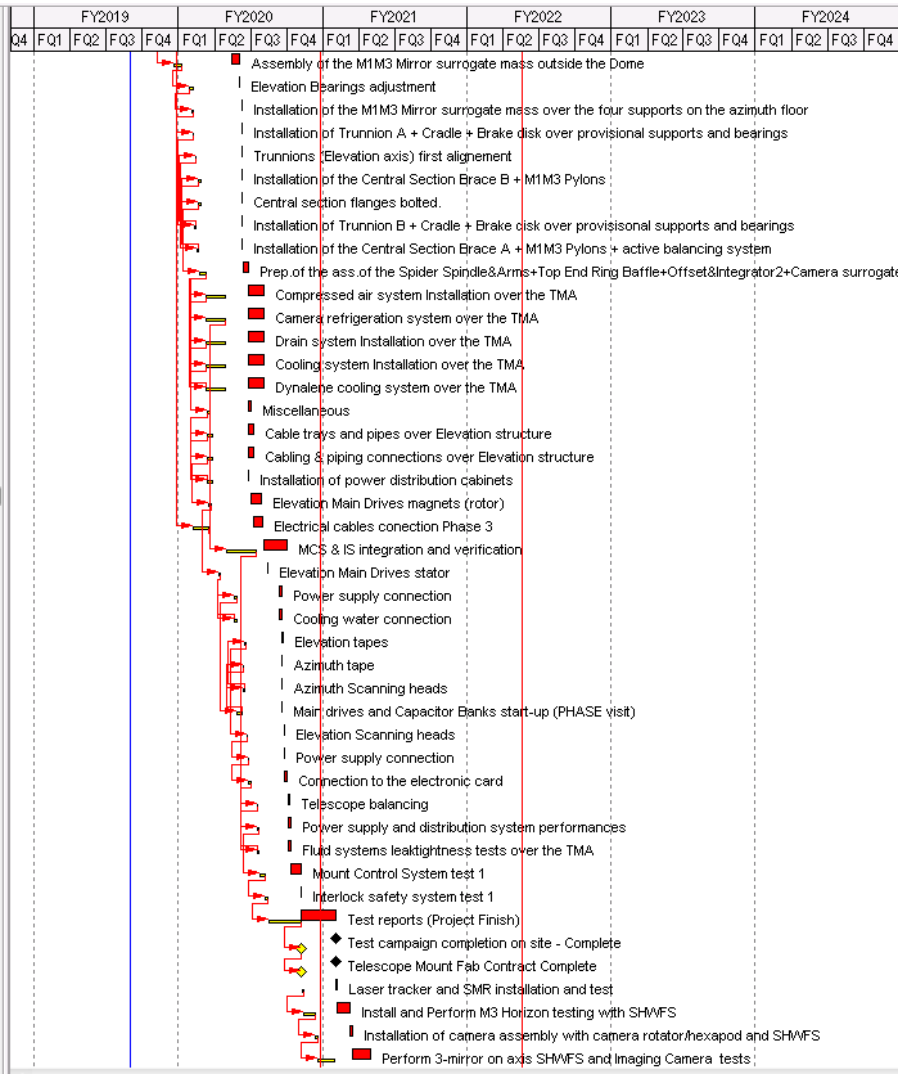
LCR-1708	Dome Facility ICD and Louver Impact	3/27/2019	RM-814 RM-826 RM-94	1.04C.04.02	None	$0	($725,390)	($8,460,358)	$3,029,950	$28,556,535
LCR-1707	Dome Stairs and Walkways CR	4/23/2019	RM-814 RM-826 RM-94	1.04C.04.02	None	$0	($276,143)	($8,736,501)	$2,753,807	$28,280,392
LCR-1783	M2 Baffle and Lifting Fixture Schedule Extension		RM-894	1.04C.14.04	None	$0	($2,180)	($8,738,680)	$2,751,627	$28,278,212
LCR-1829	Return Shipment Insurance 2 to Contingency		RM-841	1.04C.12.08	None	$150,000	$0	($8,588,680)	$2,901,627	$28,428,212
LCR-1833	Camera Refrigeration Pathfinder Scope		RM-894	1.06C.02	None	$0	($1,854)	($8,590,534)	$2,899,773	$28,426,358
LCR-1832	TMA Special Utilities		N/A	1.04C.12.19	None	$0	$0	($8,590,534)	$2,899,773	$28,426,358
Ending Contingency Balance						$236,267	($1,435,684)	($8,590,534)	$2,899,773	$28,426,358
Pending LCRs with Potential PMCS Impact										
LCR-1834	TSSW Adding Next Quarterly Scope			1.04C.15	None	$0	($201,435)	($8,791,969)	$2,698,338	$28,224,923
LCR-1715	Remove Incomplete EIA Tracking Milestones from Project Baseline			1.06C	None	$0	$0	($8,791,969)	$2,698,338	$28,224,923
LCR-1725	Early ComCam Integration and Test			1.04C	Schedule impact ~2 months critical path		($3,000,000)	($11,791,969)	($301,662)	$25,224,923

6 Critical Path Plots

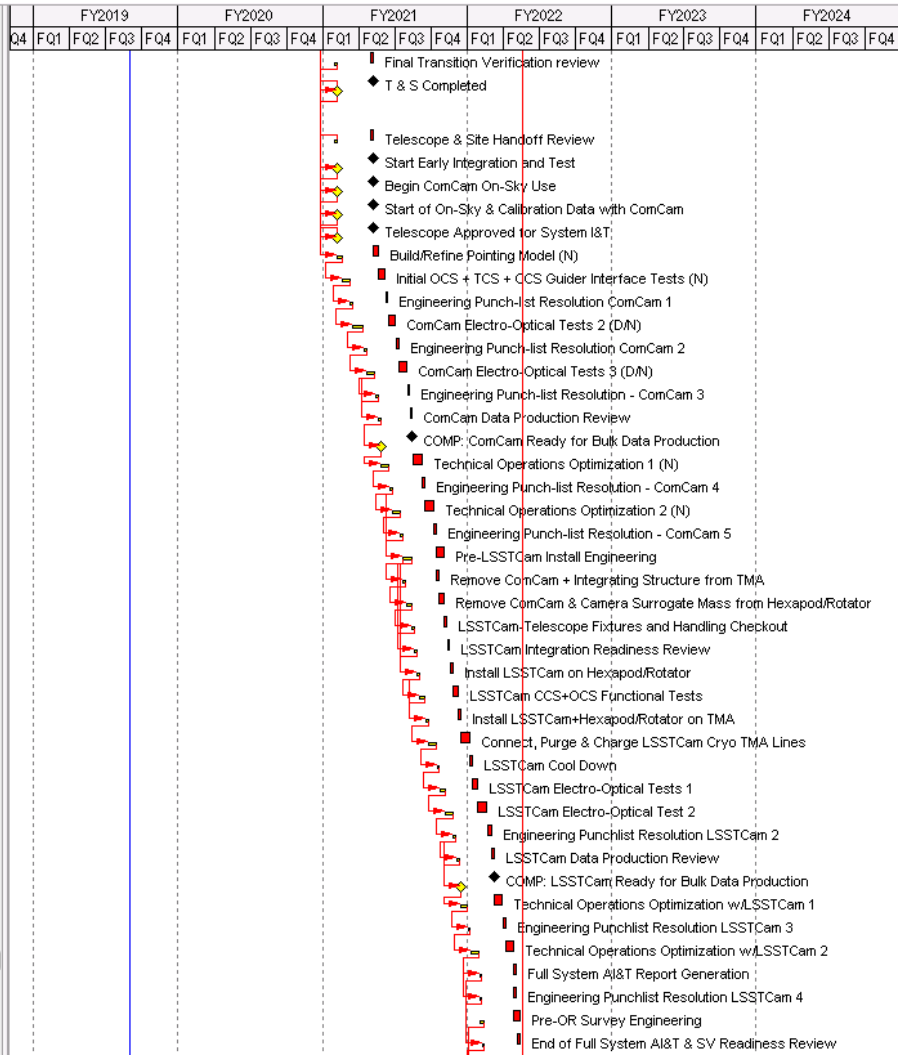
Activity Name	BL Project Start	Start	BL Project Finish	Finish	Total Float
re Buttons					
LSST May 2019 Month End Forecast					
LSST Program Timeline with Level 1 Milestones					
Telescope Subsystem Development Complete			05-Nov-20	04-Feb-21	-61
Start Early System Integration and Test (ComCam)	06-Nov-20	05-Feb-21			-61
Science Verification Complete			01-Apr-22	24-Jun-22*	-61
MREFC Program Complete			01-Apr-22	27-Jun-22*	-62
Telescope and Site Construction					
Dissassembly	03-Dec-18	10-Dec-18 A	28-Mar-19	28-Jun-19	-61
Transport to the Avilés Harbour (Break Bulk Cargo	08-Apr-19	01-Jul-19	03-May-19	17-Jul-19	-61
Transportation to the Site (Break Bulk Cargo Vesse	06-May-19	18-Jul-19	24-Jun-19	30-Sep-19	-61
Telescope Mount On Site			17-Jul-18	30-Sep-19	-61
Telescope Mount Assembly Install at site starts	07-Jun-19	01-Oct-19			-61
Installation of the Topple Block (support beam and c	17-Jun-19	01-Oct-19	24-Jun-19	11-Oct-19	-61
Assembly of the M1M3 Mirror Surrogate Mass Cart	25-Jun-19	14-Oct-19	27-Jun-19	14-Oct-19	-61
Installation of the anchor bolts on the four sectors	03-Jul-19	14-Oct-19	05-Jul-19	16-Oct-19	-61
Transport to the Dome through the lift and Instalatio	08-Jul-19	17-Oct-19	09-Jul-19	18-Oct-19	-61
Levelling and alignmet	10-Jul-19	21-Oct-19	11-Jul-19	22-Oct-19	-61
Bolted junctions between the four sectors	12-Jul-19	23-Oct-19	15-Jul-19	24-Oct-19	-61
Dimensional control and readjustment	16-Jul-19	25-Oct-19	17-Jul-19	28-Oct-19	-61
First Grouting	18-Jul-19	29-Oct-19	22-Jul-19	01-Nov-19	-60
Anchorage skids to the embedded bolts at machine	18-Jul-19	29-Oct-19	31-Jul-19	11-Nov-19	-61
Dimensional control and fine tuning	23-Jul-19	04-Nov-19	24-Jul-19	04-Nov-19	-60
Final grouting	25-Jul-19	04-Nov-19	25-Jul-19	04-Nov-19	-60
Welded junctions between sectors (seal weld)	26-Jul-19	05-Nov-19	30-Jul-19	08-Nov-19	-60
Installation of the azimuth axial hydrostatic bearings	25-Jul-19	05-Nov-19	30-Jul-19	02-Dec-19	-61
Connection to the oill supply and return pipes	25-Jul-19	05-Nov-19	31-Jul-19	11-Nov-19	-61
Application of the seal product in the four sectors	31-Jul-19	11-Nov-19	01-Aug-19	12-Nov-19	-60
Final verification	02-Aug-19	13-Nov-19	06-Aug-19	15-Nov-19	-60
Azimuth Main Drives magnets (rotor)	07-Aug-19	18-Nov-19	09-Aug-19	20-Nov-19	-60
Support A installation over the azimuth ring and tem	12-Aug-19	21-Nov-19	14-Aug-19	25-Nov-19	-60
Support B installation over the azimuth ring and tem	15-Aug-19	26-Nov-19	16-Aug-19	27-Nov-19	-60
Central Keel Beam installation (with capacitor bank	19-Aug-19	02-Dec-19	20-Aug-19	02-Dec-19	-60
Bolting Central Keel Beam with Support A and Supp	21-Aug-19	02-Dec-19	27-Aug-19	06-Dec-19	-60
Installation of the azimuth horizontal and vertical se	28-Aug-19	09-Dec-19	03-Sep-19	13-Dec-19	-60
Installation of the azimuth brakes callipers	20-Aug-19	09-Dec-19	23-Aug-19	28-Jan-20	-61
Installation of the azimuth radial hydrostatic bearing	06-Aug-19	09-Dec-19	19-Aug-19	09-Dec-19	-61
Circular beams A & B over the azimuth ring and bolt	04-Sep-19	16-Dec-19	09-Sep-19	19-Dec-19	-60
First verification of the Azimuth Structure main part	10-Sep-19	20-Dec-19	11-Sep-19	06-Jan-20	-60
Floor support structure & floor (including Az. Hatch	12-Sep-19	07-Jan-20	16-Sep-19	09-Jan-20	-60
Electrical cables Laydown Phase 1	17-Sep-19	10-Jan-20	25-Sep-19	21-Jan-20	-60
Electrical cables conection Phase 1	26-Sep-19	22-Jan-20	23-Oct-19	05-Feb-20	-60
First Start-up Oil System (Azimuth axis)	18-Sep-19	30-Jan-20	19-Sep-19	11-Feb-20	-61
Electrical cables conection Phase 2	24-Oct-19	06-Feb-20	07-Nov-19	07-Apr-20	-60



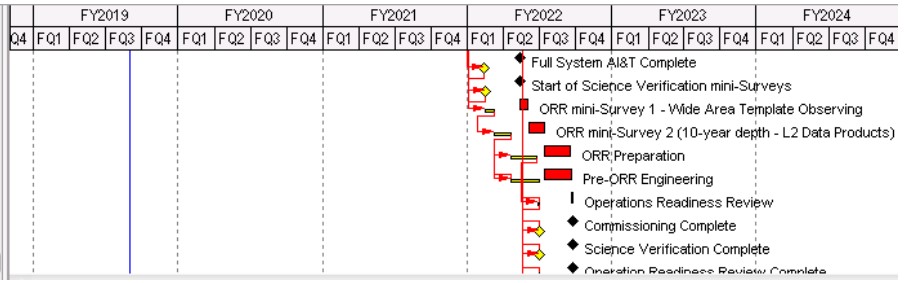
Activity Name	BL Project Start	Start	BL Project Finish	Finish	Total Float
Assembly of the M1M3 Mirror surrogate mass outs	20-Sep-19	12-Feb-20	08-Oct-19	02-Mar-20	-61
Elevation Bearings adjustment	28-Oct-19	03-Mar-20	08-Nov-19	03-Mar-20	-61
Installation of the M1M3 Mirror surrogate mass ove	04-Nov-19	10-Mar-20	06-Nov-19	10-Mar-20	-61
Installation of Trunnion A + Cradle + Brake disk ove	07-Nov-19	10-Mar-20	08-Nov-19	10-Mar-20	-61
Trunnions (Elevation axis) first alignement	13-Nov-19	11-Mar-20	15-Nov-19	11-Mar-20	-61
Installation of the Central Section Brace B + M1M3 F	22-Nov-19	11-Mar-20	26-Nov-19	11-Mar-20	-61
Central section flanges bolted.	22-Nov-19	11-Mar-20	25-Nov-19	11-Mar-20	-61
Installation of Trunnion B + Cradle + Brake disk ove	12-Nov-19	11-Mar-20	12-Nov-19	11-Mar-20	-61
Installation of the Central Section Brace A + M1M3 F	18-Nov-19	11-Mar-20	21-Nov-19	11-Mar-20	-61
Prep.of the ass.of the Spider Spindle&Arms+Top En	25-Nov-19	12-Mar-20	10-Dec-19	25-Mar-20	-61
Compressed air system Installation over the TMA	11-Dec-19	26-Mar-20	29-Jan-20	04-May-20	-61
Camera refrigeration system over the TMA	11-Dec-19	26-Mar-20	29-Jan-20	04-May-20	-61
Drain system Installation over the TMA	11-Dec-19	26-Mar-20	29-Jan-20	04-May-20	-61
Cooling system Installation over the TMA	11-Dec-19	26-Mar-20	29-Jan-20	04-May-20	-61
Dynalene cooling system over the TMA	11-Dec-19	26-Mar-20	29-Jan-20	04-May-20	-61
Miscellaneous	12-Dec-19	27-Mar-20	19-Dec-19	03-Apr-20	-61
Cable trays and pipes over Elevation structure	12-Dec-19	27-Mar-20	27-Dec-19	08-Apr-20	-61
Cabling & piping connections over Elevation structu	12-Dec-19	27-Mar-20	27-Dec-19	08-Apr-20	-61
Installation of power distribution cabinets	12-Dec-19	27-Mar-20	27-Dec-19	27-Mar-20	-61
Elevation Main Drives magnets (rotor)	17-Dec-19	01-Apr-20	23-Dec-19	28-Apr-20	-61
Electrical cables conection Phase 3	08-Nov-19	08-Apr-20	16-Dec-19	01-May-20	-60
MCS & IS integration and verification	30-Jan-20	05-May-20	16-Apr-20	03-Jul-20	-61
Elevation Main Drives stator	10-Jan-20	13-May-20	16-Jan-20	13-May-20	-61
Power supply connection	19-Feb-20	12-Jun-20	25-Feb-20	18-Jun-20	-61
Cooling water connection	19-Feb-20	12-Jun-20	25-Feb-20	18-Jun-20	-61
Elevation tapes	17-Mar-20	19-Jun-20	20-Mar-20	23-Jun-20	-61
Azimuth tape	12-Mar-20	19-Jun-20	12-Mar-20	19-Jun-20	-61
Azimuth Scanning heads	13-Mar-20	19-Jun-20	16-Mar-20	19-Jun-20	-61
Main drives and Capacitor Banks start-up (PHASE	26-Feb-20	19-Jun-20	11-Mar-20	19-Jun-20	-61
Elevation Scanning heads	23-Mar-20	24-Jun-20	24-Mar-20	24-Jun-20	-61
Power supply connection	25-Mar-20	25-Jun-20	25-Mar-20	25-Jun-20	-61
Connection to the electronic card	26-Mar-20	26-Jun-20	02-Apr-20	03-Jul-20	-61
Telescope balancing	17-Apr-20	06-Jul-20	17-Apr-20	08-Jul-20	-61
Power supply and distribution system performance	17-Apr-20	06-Jul-20	22-Apr-20	10-Jul-20	-61
Fluid systems leaktightness tests over the TMA	17-Apr-20	06-Jul-20	21-Apr-20	10-Jul-20	-61
Mount Control System test 1	23-Apr-20	13-Jul-20	07-May-20	05-Aug-20	-61
Interlock safety system test 1	08-May-20	06-Aug-20	15-May-20	06-Aug-20	-61
Test reports (Project Finish)	18-May-20	06-Aug-20	07-Aug-20	02-Nov-20	-61
Test campaign completion on site - Complete			07-Aug-20	02-Nov-20	-61
Telescope Mount Fab Contract Complete			07-Aug-20	02-Nov-20	-61
Laser tracker and SMR installation and test	10-Aug-20	03-Nov-20	12-Aug-20	05-Nov-20	-61
Install and Perform M3 Horizon testing with SHWFS	13-Aug-20	06-Nov-20	10-Sep-20	07-Dec-20	-61
Installation of camera assembly with camera rotato	11-Sep-20	08-Dec-20	17-Sep-20	14-Dec-20	-61
Perform 3-mirror on axis SHWFS and Imaging Came	18-Sep-20	15-Dec-20	29-Oct-20	28-Jan-21	-61



Activity Name	BL Project Start	Start	BL Project Finish	Finish	Total Float
Final Transition Verification review	30-Oct-20	29-Jan-21	05-Nov-20	04-Feb-21	-61
T & S Completed			05-Nov-20	04-Feb-21	-61
Systems Engineering and Commissioning					
Telescope & Site Handoff Review	30-Oct-20	29-Jan-21	05-Nov-20	04-Feb-21	-61
Start Early Integration and Test	06-Nov-20	05-Feb-21			-61
Begin ComCam On-Sky Use	06-Nov-20	05-Feb-21			-61
Start of On-Sky & Calibration Data with ComCam	06-Nov-20	05-Feb-21			-61
Telescope Approved for System I&T			06-Nov-20	05-Feb-21	-61
Build/Refine Pointing Model (N)	06-Nov-20	05-Feb-21	19-Nov-20	18-Feb-21	-58
Initial OCS + TCS + CCS Guider Interface Tests (N)	20-Nov-20	19-Feb-21	07-Dec-20	05-Mar-21	-58
Engineering Punch-list Resolution ComCam 1	09-Dec-20	08-Mar-21	15-Dec-20	12-Mar-21	-58
ComCam Electro-Optical Tests 2 (D/N)	16-Dec-20	15-Mar-21	11-Jan-21	02-Apr-21	-58
Engineering Punch-list Resolution ComCam 2	12-Jan-21	05-Apr-21	19-Jan-21	09-Apr-21	-58
ComCam Electro-Optical Tests 3 (D/N)	20-Jan-21	12-Apr-21	09-Feb-21	30-Apr-21	-58
Engineering Punch-list Resolution - ComCam 3	10-Feb-21	03-May-21	16-Feb-21	07-May-21	-58
ComCam Data Production Review	17-Feb-21	10-May-21	23-Feb-21	14-May-21	-58
COMP: ComCam Ready for Bulk Data Production			23-Feb-21	14-May-21	-58
Technical Operations Optimization 1 (N)	24-Feb-21	17-May-21	17-Mar-21	07-Jun-21	-58
Engineering Punch-list Resolution - ComCam 4	18-Mar-21	08-Jun-21	24-Mar-21	14-Jun-21	-58
Technical Operations Optimization 2 (N)	25-Mar-21	15-Jun-21	14-Apr-21	06-Jul-21	-58
Engineering Punch-list Resolution - ComCam 5	15-Apr-21	07-Jul-21	21-Apr-21	13-Jul-21	-58
Pre-LSSTCam Install Engineering	22-Apr-21	14-Jul-21	12-May-21	03-Aug-21	-58
Remove ComCam + Integrating Structure from TMA	22-Apr-21	14-Jul-21	28-Apr-21	20-Jul-21	-58
Remove ComCam & Camera Surrogate Mass from I	29-Apr-21	21-Jul-21	12-May-21	03-Aug-21	-58
LSSTCam-Telescope Fixtures and Handling Checkc	13-May-21	04-Aug-21	19-May-21	10-Aug-21	-58
LSSTCam Integration Readiness Review	20-May-21	11-Aug-21	26-May-21	17-Aug-21	-60
Install LSSTCam on Hexapod/Rotator	27-May-21	18-Aug-21	02-Jun-21	24-Aug-21	-59
LSSTCam CCS+OCS Functional Tests	03-Jun-21	25-Aug-21	16-Jun-21	07-Sep-21	-59
Install LSSTCam+Hexapod/Rotator on TMA	17-Jun-21	08-Sep-21	23-Jun-21	14-Sep-21	-59
Connect, Purge & Charge LSSTCam Cryo TMA Line	24-Jun-21	15-Sep-21	15-Jul-21	05-Oct-21	-59
LSSTCam Cool Down	16-Jul-21	06-Oct-21	22-Jul-21	13-Oct-21	-59
LSSTCam Electro-Optical Tests 1	23-Jul-21	14-Oct-21	05-Aug-21	27-Oct-21	-59
LSSTCam Electro-Optical Test 2	06-Aug-21	28-Oct-21	26-Aug-21	19-Nov-21	-59
Engineering Punchlist Resolution LSSTCam 2	27-Aug-21	22-Nov-21	02-Sep-21	30-Nov-21	-61
LSSTCam Data Production Review	03-Sep-21	01-Dec-21	10-Sep-21	07-Dec-21	-61
COMP: LSSTCam Ready for Bulk Data Production	13-Sep-21	08-Dec-21			-61
Technical Operations Optimization w/LSSTCam 1	13-Sep-21	08-Dec-21	01-Oct-21	28-Dec-21	-61
Engineering Punchlist Resolution LSSTCam 3	04-Oct-21	29-Dec-21	08-Oct-21	04-Jan-22	-61
Technical Operations Optimization w/LSSTCam 2	11-Oct-21	05-Jan-22	29-Oct-21	26-Jan-22	-61
Full System AI&T Report Generation	01-Nov-21	27-Jan-22	05-Nov-21	02-Feb-22	-61
Engineering Punchlist Resolution LSSTCam 4	01-Nov-21	27-Jan-22	05-Nov-21	02-Feb-22	-61
Pre-OR Survey Engineering	01-Nov-21	27-Jan-22	12-Nov-21	09-Feb-22	-61
End of Full System AI&T & SV Readiness Review	08-Nov-21	03-Feb-22	12-Nov-21	09-Feb-22	-61



Activity Name	BL Project Start	Start	BL Project Finish	Finish	Total Float
Full System AI&T Complete			12-Nov-21	09-Feb-22	-61
Start of Science Verification mini-Surveys	15-Nov-21	10-Feb-22			-61
ORR mini-Survey 1 - Wide Area Template Observin	15-Nov-21	10-Feb-22	07-Dec-21	03-Mar-22	-61
ORR mini-Survey 2 (10-year depth - L2 Data Produ	08-Dec-21	04-Mar-22	19-Jan-22	14-Apr-22	-61
ORR Preparation	20-Jan-22	15-Apr-22	25-Mar-22	17-Jun-22	-61
Pre-ORR Engineering	20-Jan-22	15-Apr-22	30-Mar-22	22-Jun-22	-61
Operations Readiness Review	28-Mar-22	20-Jun-22	01-Apr-22	24-Jun-22	-61
Commissioning Complete			01-Apr-22	24-Jun-22	-61
Science Verification Complete			01-Apr-22	24-Jun-22	-61
Operation Readiness Review Complete			01-Apr-22	24-Jun-22	-61



7 Detailed Project Progress Status

Project Office

- The LSST Project Office (LSSTPO) focused on coordinating Construction activities and developing additional details of the Commissioning plan.
- LSST issued a message about the new LSST data framework, acknowledging the funding agencies' decision on the way data rights and data access will be handled during LSST Operations. Following the agencies' approval, the LSST project team soon will publish data rights and data access policies for LSST.
- Chief Scientist T. Tyson attended the LSST@Asia meeting 17-24 May in Sydney Australia. He reported on the status of the LSST project, participated in two panel discussions and chaired a session. By far the most significant development was the real-time announcement that international collaborators would in the future earn LSST data rights through in-kind contributions intended primarily to offset operations cost – as opposed to the existing arrangement where monetary contributions would have been made. Some talking points, which were developed by the agencies in consultation with the project, were announced. Overall, most Asian partners (current and potential) were confused regarding what would constitute in-kind.

Safety

- LSST safety coordinators continued Summit site and Base Facility construction contractor inspections. Summit inspection reports and corrective actions can be found in DocuShare Collection-4422. Base Facility inspection reports and corrective actions can be found in DocuShare Collection-4863.
- Weekly Summit site coordination meetings and the monthly Summit Safety Meeting with contractor safety personnel continued. Topics of the meetings included work coordination, vehicle over-speed observations, correct use and observance of work area safety delimitations, status of corrective actions from inspections, and review of delivery work procedures. The reports and attendance records for the meeting can be found in Collection-5642.
- Safety Coordinator S. Romero provided safety support during the Coating Plant final review and for the successful transportation of the M1M3 (Primary-Tertiary Mirror) optic from the Port of Coquimbo to the LSST site at Cerro Pachón. During the Coating Plant final review, Sandra worked with the Coating team to perform hazards analysis. She also provided guidance and oversight during the planning for and actual transportation of M1M3 to the summit.
- Safety coordinators provided safety surveillance during successful M2 (Secondary Mirror) surrogate tests on the summit. Safety coordinators previously had provided guidance during procedures and task planning.
- The Safety team provided training and guidance for workers' safe travel to and from the summit during adverse weather. In particular, the team performed snow chains installation training, and an LSST Safety Recommendation provided guidance for monitoring tire tread

wear. The recommendation warned of irregular tire wear due to damping and improper alignment or tire pressure. It recommended that wear be no greater than 3 mm even when the standard requires a minimum of 1.6 mm. The recommendation also demonstrated tires' tread wear indicators (TWIs), which are projections within the tread grooves designed to give a visual indication of the degree of tread wear. English and Spanish language versions of the recommendation are archived in DocuShare.

- AURA in Chile held the fifth annual Safety Workshop 27-31 May at GEMINI South. Managers and Supervisors from LSST, GEMINI, National Optical Astronomy Observatory (NOAO) and Southern Astrophysical Research (SOAR) telescope participated in training sessions and discussions. The training was facilitated by Hector Escarcega, a bilingual trainer and motivational speaker with 28 years of experience as a risk management occupational health safety professional. He also led a management training session 30 May.
- Two accidents were reported this month, resulting in either no or minor injuries. On 2 May, an employee for the Base Facility electrical contractor received an electrical shock resulting in visual dazzles. While connecting cables between UPS and a battery bank, the worker's wrench made contact with the battery's energized bar, causing an electric arc. The employee was immediately transferred to Mutual de Seguridad C.CH.C de La Serena for medical care. On 7 May, a dump truck driver jumped out of the vehicle's cabin when it began to unexpectedly roll back toward the Cerro Pachón road's guard rail. The cause of the truck's loss of air pressure and sudden backing are under investigation. The driver was uninjured, and the truck was undamaged; however, the truck blocked the road for a time, necessitating a temporary light vehicle bypass until it could be moved safely.

Compliance

- The Compliance and Quality Administrator (CQA) is part of an AURA working group developing verification and compliance procedures for contractual requirements such as terms and conditions (T&Cs) and financial/administrative terms and conditions (FATCs).
- The CQA began auditing all fiscal year 2018 (FY18) travel expense reports for allowability and documentation support.
- The CQA provided guidance on temporary dependent care costs, information classification and travel.

Science

- University of California Davis (UC Davis) team members continued to assist with Raft Tower Module (RTM) channel loss mitigation activities at SLAC. The team disassembled and vacuum cleaned RTMs constructed of ITL sensors then performed electro optical (EO) testing with bias and dark images.
- Following analysis of data from the charge coupled device (CCD) currently in the Auxiliary Telescope (AuxTel) camera, the team and determined it should be replaced. In collaboration with the vendor and Brookhaven National Laboratory (BNL), the team selected a replacement CCD.
- UC Davis Physicist S. Schmidt and UW scientist S. Daniel reviewed for completeness all the Observatory System Specifications' (OSS) major verification elements dealing with

photometry and astrometry. Sam also wrote up test cases for OSS-REQ numbers 0726, 0277, 0282, 0336 and 0387.

- T. Tyson attended an LSST-LIGO meeting 2-3 May at Columbia University. The meeting focused on modes of efficient LSST follow-up investigations for gravitational wave events. By the mid-2020s, the error regions for the gravitational wave source will shrink to tens of square degrees, enabling efficient LSST identification of the source and rapid handoff to spectroscopic follow-up. However, as the source gets fainter, or the gravitational wave error area grows, LSST takes much longer to paint the area with five-band deep imaging. This causes a runaway of background contamination – in that over a longer time, there are more "ordinary" transients making it more difficult to find the one gravitational wave source. The increased sensitivity of LIGO+Virgo+KAGRA will result in more events and smaller error areas, enabling a more selective LSST strategy that can avoid the transient contamination runaway.

Communications

- The Communications team documented M1M3's arrival in Chile and its journey to Cerro Pachón. A press release also was issued.
- The team prepared for media and VIP visitors coming to LSST before and after eclipse days. The team also distributed eclipse safety glasses to staff and contractors in Chile.
- The post on LSST's Facebook page with a photo of M1M3 reaching the summit and being stored in the on-site warehouse reached the most users in May (8,938). The project's Twitter post announcing the LSST Corporation's Data Science Fellowship Program is accepting applications was the most popular tweet, reaching 24,258 individuals.

Social Media Statistics				
Month	**Facebook Likes**	**Change**	**Twitter Followers**	**Change**
May 2019	5,392	102	5,601	182
April	5,290	310	5,419	175
March	4,980	108	5,244	177
February	4,872	48	5,067	127
January	4,824	78	4,940	126
December	4,746	51	4,814	125
November	4,695	133	4,689	189
October	4,562	135	4,500	136
September	4,427	104	4,364	122
August	4,323	96	4,242	184
July	4,227	52	4,058	52
June	4,175	85	4,006	109
May 2018	4,090	39	3,897	129

Systems Engineering (SE) and Commissioning

- System Integration, Test and Commissioning (SIT-Com) lead and Systems Scientist C. Claver continued collaboration with the Telescope and Site (T&S) team to optimize overall assembly integration and verification (AIV) efforts and to recover schedule. The goal is to have the optimized re-plan incorporated in the Project's June baseline.
- The SIT-Com team instantiated a local private network in Tucson to support AuxTel software integration.
- The team supported the pre-shipment review of the Commissioning Camera (ComCam) at SLAC. ComCam is expected to arrive in Tucson in late June.
- Senior Systems Engineer M. Rodriguez implemented the JIRA-based Summit work planning tool that will be used for daily coordination of Summit site activities requiring shared resources. Michael also deployed a test version of the travel management JIRA project that LSST administrative staff will use to coordinate travel arrangements and needs for project members visiting La Serena and the summit.
- Assistant Commissioning Scientist B. Stalder verified successful factory acceptance test of differential image motion monitors (DIMMs). Installation and on-site acceptance at the summit are expected in July.
- A one-time SE intern has been offered a full-time position as System Verification Engineer.
- The Commissioning team will add a summer student intern who will support ComCam and Calibration testing.

Telescope and Site (T&S)

- Continuing Summit Facility post-construction projects included installation of bridge supports to connect the mirror cart rails to the Pflow platform lift, completion of improvements to the Camera clean/white room areas, electrical and data infrastructure improvements at the main and AuxTel facility, and initiation of road and platform improvements. The newly completed summit warehouse received the M1M3 optic 11 May. Subsequently, the mirror transport box was seismically anchored to the facility floor, and a contract to close the end wall was executed. The project also received two Dynalene chillers that were moved into the telescope pier where they will be installed in the future. Work continued on the Pachón hotel addition's main concrete structure; the project anticipates the addition will be complete and ready for LSST use by the end of August.
- LSST continues to closely monitor and assist in the advancement of all Dome construction activities. In Chile, dome cladding installation began in parallel with continuing placement and adjustment of the steel structure's final pieces; however, on-site efforts were slowed by the arrival of winter weather. LSST management and engineers continued on-site assistance to vendor European Industrial Engineering (EIE), including management of purlins' and other structural pieces' procurement from Chilean fabricators. Change orders were enacted to incorporate design revisions and to facilitate procurement of remaining hardware components. At the vendor's Italian fabrication sites, the large louver panels were completed and shipped; fabrication of drives, overhead crane and other mechanisms continued.

With the Telescope Mount Assembly's (TMA) pending on-site arrival in September, LSST and EIE have begun discussing ways to start TMA assembly in the event Dome substantial completion has yet to occur when the TMA arrives. Possible solutions include a provisional friction-drive system to allow dome rotation and a temporary bridge crane for mount assembly until the final bridge crane can be delivered.

- Vendor Asturfeito continued TMA disassembly, packing and shipping. Eight shipping containers of TMA components either have been received on-site in Chile or are now in overseas shipment. The vendor has commenced action items from the April on-site review, including site improvements to facilitate TMA integration and preparation of the pier for initial installation work. A contract for TMA-related utilities' design kicked off in May; it includes design of Facility-provided services such as hydrostatic bearing oil lines, low-temperature glycol lines and electrical connections. Updated overall schedules have been received and reviewed. The large bulk shipments of TMA components are now scheduled to be delivered to the port 19 July for subsequent shipment no later than 30 July.
- The M2 team completed integration and testing of the cell and surrogate at the Summit Facility. Software refinements required to enable support actuators' and systems' testing and verification also were completed. This was the first set of tests; the second set will happen next year, including required software refinements and software abstraction layer (SAL) updates. Coating tests were performed in the newly commissioned Coating Plant utilizing the surrogate with witness plates. Preparations for full M2 mirror coating began in May, including final definition of handling procedures and preparation of materials for a coating readiness review to be held on-site in June. The M2 Hexapod was received on site and has been stored for future integration. M2 Technical Manager J. Bagnasco left the project at the end of the month, following completion of his on-site activities. His responsibilities have been transferred to Optics Lead R. Tighe and others on the T&S engineering team.
- The M1M3 optic was safely received and secured in the summit warehouse 11 May. Its airbag supports and anchorage are being regularly checked. The M1M3 cart was successfully assembled and tested on-site during the week 13 May. An engineer from cart manufacturer CAID Industries helped oversee assembly, verified the operation and provided cart use instruction to the LSST team.
- In the first weeks of May, vendor Von Ardenne (VA) completed on-site assembly and testing of the Coating Plant. Final testing included performance verification with M2 and M1M3 witness samples. Then the plant was reconfigured for the M2 mirror, which will be the first optic to receive its coating for operational scientific use. The full coating plant's final acceptance test in Chile occurred 21-25 May. Test results and verification procedures were formally reviewed, resulting in acceptance by LSST Systems Engineering. VA was further contracted and scheduled to send technical representatives to assist the LSST team during the first use of the chamber for an operational coating (M2) scheduled for mid-July.
- Base Facility construction progress included final testing of utility systems and development of a punch list for final finishes and interior/exterior details. IT infrastructure installation continued, assisted by temporary contracted electricians under the supervision of the LSST IT team. Meetings of the partners group, i.e. AURA, LSST and NOAO, focused on final coordination, change orders, site lighting and signage, and the imminent transition to occupancy. LSST offices' furnishings

procurement has begun, vendor layouts have been developed, and staff office assignments have been identified.

- Required AuxTel mount and dome mechanical work has been completed. To prepare for optics installation, the team performed installation and removal practice runs using surrogates. Senior Engineering Associate J. Andrew and Integration Mechanical Engineer M. Rivera witnessed the practice runs and refined their handling and safety procedures activities. The software team's late-May visit resulted in successful AuxTel control system implementation.
- The Software team assisted with M2 simulator/support system debugging, participated in Coating Plant acceptance activities, worked with vendor INRIA Chile on LSST Observing Visualization Environment development, and initiated contracted support for LabVIEW programming. A contingent of the Software team also successfully integrated and tested the AuxTel control system in Chile. Previous Software manager K. Robison left the project, and A. Clements was promoted to fill the position.

Camera

Systems Integration

- *The Systems Integration team continued work on verification and test plans and acceptance reviews for various Camera subsystems.*

Sensors

- *Vendors ITL and e2v have completed and delivered all sensors per contract.*

Science Rafts and Corner Rafts

- *BNL continued phased delivery of refurbished RTMs from to SLAC. Thus far, seven RTMs have been delivered to the IR2 cleanroom facility. Phased delivery is expected to continue into the third quarter of 2019. At SLAC, the Integration and Test (I&T) team re-verifies refurbished RTMs and prepares them for integration within the cryostat. Six rafts have been re-verified and deemed ready for integration in the cryostat, which is currently planned to start in June 2019. Raft refurbishment is maintaining schedule and remains ahead of the planned integration need date.*
- *The following table summarizes the current status of each RTM and explains the four categories of planned activity identified to address the various raft states.*

Summary of RTMs under assembly as of May 23, 2019					
RTM	**Sensors**	**Location**	**Original State[3]**	**Plan[4]**	**Current Status**
RTM1	ITL	SLAC	4 dead channels	B	Glow present on one sensor after initial refurbishment. Sensor replaced again at BNL and received at SLAC on 5/20.
RTM2	e2v	SLAC	1 dead channel	C	Completed at BNL and received at SLAC on 5/20.
RTM3	e2v	BNL	0 dead channels	C	Disassembled at SLAC and received at BNL.
RTM4	e2v	BNL	1 dead channel	C	Disassembled at SLAC and received at BNL.
RTM5	e2v	BNL	0 dead channels	C	Disassembled at SLAC and received at BNL.
RTM6	e2v	BNL	Several shorts	A	Completed at BNL and expected to ship to SLAC on 5/31.
RTM7	e2v	SLAC	0 dead channels	C	Disassembled at SLAC and received at BNL.
RTM8	ITL	SLAC	1 dead channel	D	COMPLETED: Ready for integration. One dead channel remains.
RTM9	e2v	SLAC	1 glowing sensor (will be removed)	A	Completed at BNL. Received at SLAC on 5/20.
RTM10	ITL	BNL	3 high-noise sensors	A	Completed at BNL. Received at SLAC in April and under reverification at SLAC.
RTM11	ITL	SLAC	3 dead channels	B	COMPLETED: Ready for integration.

[3] State prior to channel-loss mitigation

[4] Migration plans A through D:

A. RTM to be disassembled, cleaned, retrofitted, re-assembled and qualified at BNL and then re-verified at SLAC: Applies: to 1) RTMs that were returned to BNL that require sensor replacement due to permanent damage or performance issues; and 2) incomplete RTMs at BNL that are currently on hold. There are five RTMs in this category, all of which will be re-verified at SLAC.

B. RTM to be disassembled, cleaned, retrofitted, re-assembled at BNL, and then re-verified at SLAC: Applies to 1) RTMs that were returned to BNL that do NOT require sensor replacement; and 2) completed/tested RTMs at BNL that were never shipped to SLAC and are currently on hold at BNL. There are six RTMs in this category, all of which will be re-verified at SLAC.

C. (e2v only) RTM to be disassembled at SLAC and the RSA will be shipped to BNL for cleaning and retrofitting, and then returned to SLAC for re-assembly and re-verification at SLAC: Applies to e2v-based RTMs currently at SLAC (e2v-based RTMs require sensor removal due to limited access to the wire bonds while installed on the RSA). There are eight RTMs in this category, all of which will be re-verified at SLAC.

D. (ITL only) RTM to be disassembled, cleaned, retrofitted, reassembled and re-verified at SLAC: Applies to ITL-based RTMs already at SLAC. There are four RTMs in this category.

RTM12	e2v	SLAC	0 dead channels	C	Disassembled at SLAC and expected to be shipped to BNL on 5/22.
RTM13	e2v	SLAC	0 dead channels	C	Disassembled at SLAC and expected to be shipped to BNL on 5/22.
RTM14	ITL	SLAC	1 dead channel	D	Awaiting disassembly and cleaning at SLAC.
RTM15	ITL	SLAC	1 dead channel	D	Awaiting disassembly and cleaning at SLAC.
RTM16	e2v	SLAC	0 dead channels	C	Disassembled at SLAC and expected to be shipped to BNL on 5/22.
RTM17	e2v	BNL	Complete, on hold	B	COMPLETED: Ready for integration.
RTM18	ITL	SLAC	0 dead channels	D	Awaiting start of disassembly.
RTM19	ITL	BNL	1 high CTE sensor	A	Sensor reassembly underway at BNL to address a glowing sensor.
RTM20	ITL	BNL	Complete, on hold	B	COMPLETED: Ready for integration. One dead channel remains.
RTM21	e2v	SLAC	Complete, on hold	B	Received at SLAC in April and waiting to be reverified.
RTM22	e2v	SLAC	Incomplete	A	COMPLETED: Ready for integration.

- *Two of the five required corner RTMs (CRTMs) have completed acceptance testing. All five CRTMs were constructed by October 2018, but acceptance testing was delayed because key personnel were diverted to work on the science raft channel loss issue. The team expects to complete CRTM testing in July.*

Optics

- *Arizona Optical Systems (AOS) attached the L1 lens to the L1-L2 assembly. L2 was attached last summer. Transmitted wavefront error (TWE) testing of the integrated assembly showed more astigmatism than expected. The assembly meets optical requirements, but stress in flexures that attach the lenses to the assembly reduces margin for seismic events to just less than 0 (-0.06). The astigmatism appears to be due to slightly out-of-plane shims between the L1 and L2 cells. The shims are used to adjust L1-to-L2 alignment. The team at AOS is re-shimming to minimize planarity errors. Delivery of the L1-L2 assembly has been rescheduled to the end of June to address the issue. In addition, a DX project is requiring AOS to divert resources away from LSST, causing some slight additional delays but with no risk to the camera critical path.*
- *Thales SESO (TSESO) continued integration of L3 with its titanium barrel, which surrounds the lens and will provide attachment to the cryostat housing.*

- *TSESO expects to finish polishing the z-band filter glass later this month. Processing of the u-, g- and y-bands continued. Filter-coating vendor Materion has begun the qualification process for the r-band filter. As previously reported, early results have confirmed that the filter coating was successful.*

Camera Body and Mechanisms, Shutter, and Filter Exchange

- *At IR2, bonding of sub-assemblies to the Camera body housing has been completed. The Camera body shroud was delivered and is undergoing bonding to subassemblies. Preparations to verify and test the Camera body purge systems are underway.*
- *As previously reported, assembly of the production shutter at SLAC will be delayed due to the long lead time for delivery of the shutter blade guides. The guides are custom-made by a vendor in Japan. The project is taking steps to expedite delivery from the vendor. The shutter delay will not impact Camera schedule or cost.*
- *As reported last month, a serious injury accident 11 April at Laboratoire de Physique Nucleaire et des Hautes Energies (LPNHE) has delayed integration of the production carousel with the Camera back flange. LPNHE has suspended Carousel work while the incident is being investigated and corrective actions are taken. A team from the Camera project visited LPNHE 22-24 May to review implementation of corrective safety measures. These measures are critical because similar testing is planned at SLAC after delivery of the carousel from LPNHE.*

  The person injured in the incident is recovering rapidly. The project expects the incident will impact the carousel schedule by about two months; however, the delay is not expected to impact Camera early delivery, although the new delivery date of September 2019 has eroded the schedule float significantly to a few weeks.
- *Centre de Physique des Particules de Marseille (CPPM) and Laboratory of Subatomic Physics & Cosmology (LPSC) completed standalone testing of the first of two filter auto-changers and the first of two filter loaders, respectively. Both units were shipped to LPNHE for combined testing with the full-scale filter exchange test bench. CPPM has completed procurement of parts for second auto-changer, and LPSC is nearly done procuring parts for the second filter loader.*

Cryostat and Refrigeration

- *Construction, testing and installation was completed for four power cabling feedthroughs between the utility trunk and the cryostat. The feedthroughs, which enable rafts to be powered in the sealed cryostat, are needed for final testing of bench for optical testing (BOT) electro-optical (EO) instrumentation. During installation of one feedthrough, the team discovered that some fasteners and washers were missing from the feedthrough terminal block. The hardware was found on the floor near the BOT. One washer is still missing. If it cannot be found on the floor, the team may have to search inside the cryostat.*
- *All six optical translation modules (OTMs) also were installed. The OTMs translate electrical signals from rafts to optical signals available for processing off-Camera. The seals for the feedthroughs and OTMs will be tested during the next cryostat pump-down.*
- *Purchase orders were issued for utility trunk vacuum chambers, which are expected to be delivered by late July. The chambers separate the utility trunk into thermally isolated areas.*

- *All I&T heat exchangers and refrigeration cabinets are now operating at IR2, and verification tests of the entire refrigeration system are underway. Testing of the two cold-system circuits has been completed, and the cold-system meets requirements. Testing of the six cryo-system circuits is expected to be completed later this month, although delayed by two weeks due to power feedthrough vacuum leaks needing repair. The cryostat has been able to maintain good vacuum, confirming the success of the power feedthrough repairs. Following refrigeration system verification, final BOT EO testing can start using the two engineering test unit (ETU) rafts currently installed within the cryostat. Successful final EO testing clears the path for integration of production RTMs.*
- *Fabrication of TMA heat exchanger parts is underway at the vendor. Delivery of the TMA cold-system parts to SLAC is expected later this month. Phased-delivery of the cryo-system parts will occur in June and July. Assembly of TMA refrigeration cabinets continued. In early May, there was minor damage to a compressor chassis that will go in one of the cryo-system cabinets. The damage occurred when the pallet supporting the chassis slipped off a wheeled transport cart at SLAC. The damage is easily fixed, and steps have been taken to prevent another incident.*
- *Following is a table that summarizes status of Camera refrigeration systems.*

Summary of Refrigeration status as of May 23, 2019				
Component(s)	**System**	**Circuits**	**Status**	**Location**
Evaporator	Camera Cryostat	2 Cold circuits	Final testing completed and successful.	SLAC
		6 Cryo circuits	Final testing underway.	SLAC
	Pathfinder Chamber	2 Cold circuits	Chamber is being fabricated and expected at SLAC by end of May.	Vendor
		2 Cryo circuits	Chamber is being fabricated and expected at SLAC by end of May.	Vendor
Heat Exchangers	I&T (to become Chile maintenance system	Vacuum Can 1: 2 Cold and 2 Cryo Circuits	Final testing of cold completed and successful. Operating in SLAC cleanroom successfully.	SLAC
		Vacuum Can 2: 4 Cryo Circuits	Final testing underway. Operating in SLAC cleanroom successfully.	SLAC
	Pathfinder	Vacuum Can 1: 2 Cold and 2	All parts from vendor in hand. Assembly underway.	SLAC

		Cryo Circuits		
	On Telescope (Chile)	Vacuum Can 1: 2 Cold and 2 Cryo Circuits	Parts received at Eden. Good progress reported. Oversight visit planned 5/22 to review workmanship.	Eden
		Vacuum Can 2: 4 Cryo Circuits	Parts received at Eden. Good progress reported. Oversight visit planned 5/22 to review workmanship.	Eden
Compressor Cabinets	I&T (to become Chile maintenance system)	2 Cold cabinets, each supporting 1 cold circuit	Final testing completed and successful.	SLAC
		2 Cryo cabinets, each supporting 3 cryo circuits	Final testing underway. Operating in SLAC cleanroom successfully.	SLAC
	On Telescope (to be used in Chile with Pathfinder first)	2 Cold cabinets, each supporting 1 cold circuit	Completed at SLAC except for some final wiring and an acceptance test.	SLAC
		2 Cryo cabinets, each supporting 3 Cryo circuits	Parts on hand. Some compressors are being repaired at MMR vendor due to some leaks and a drop incident. Being assembled at SLAC.	SLAC

Integration and Test (I&T)

- *Production RTM integration was originally anticipated to start in late May, but the project now expects about a two-week delay due to longer-than-expected OTM and feedthrough installation times caused by vacuum leaks requiring repairs on a few feedthroughs. If refrigeration testing continues to be successful, I&T will attempt to recover time later this*

month, but the team anticipates the delay may have a small impact on the schedule for Camera early delivery.

- *Assembly of the Camera integration stand continued at IR2. The stand will cradle the Camera during construction. Piers for the stand have been attached to the floor. Procurement for a Camera mass mock-up for use with the stand is underway. Procurement of Camera subassembly fixtures also continued. Those fixtures include cryostat support stand, cryostat c-hook lift fixture and Camera saddle stand, which will cradle the Camera during storage and shipment.*
- *In the computer room adjacent to the main area at the IR2 cleanroom, the Data Acquisition (DAQ) team installed hardware that will support DAQ testing later this year. DAQ provides an interface to sensors and electronics at the Camera focal plane. DAQ hardware and software translate sensor digital data to optical data for use outside the Camera (for example, the processing done at collaborating LSST institutions).*
- *I&T also continued participation in RTM refurbishment activities.*

Commissioning Camera (ComCam)

- *Final testing of the ComCam cryostat is underway at IR2 using ComRaft, the schedule mitigation raft provided by BNL. ComRaft will be used until one of the two ETUs is available for permanent use with ComCam. The pre-ship review for ComCam currently is on track for the end of this month.*

Commissioning

- *Currently, the Major Item of Equipment (MIE) Camera project forecasts that the Pathfinder compressor cabinets will be available at the end of June 2019. Storage tanks for Pathfinder cryo-system refrigeration have been filled at SLAC and prepared for shipment to the summit. Also at SLAC, the cold-system heat exchangers are cleaned, and work has started on the cryo-system heat exchangers. The one cryo-coil needing repair was fixed successfully by SLAC technicians. The Pathfinder heat loads have been designed and are in production at SLAC. Construction of the vacuum vessel that will contain the heat exchangers is under way.*

Data Management (DM)

- The team conducted the first DM Operations Rehearsal, during which a multi-institutional team, including members of the LSST Pre-Operations project, worked together to simulate nominal operational procedures over a three-day period. This included sending data from Chile to National Center for Supercomputing Applications (NCSA), processing it and performing quality assurance on the results.
- The team made important LSST Science Platform (LSP) upgrades. A Kubernetes log aggregation service was deployed for LSP instances in the Data Facility at NCSA. Most significantly, the Firefly image display and portal system were upgraded to support a new service-discovery mechanism based on the Redis in-memory structured data store. This provides an alternative to the previous multicast-based approach, which was not well supported in cloud environments. Firefly also has been fully integrated into the Data Facility's authentication system.
- The Data Release Production group undertook an intensive "sprint" to integrate the SCARLET

deblender with the rest of the code base. This is a key step toward verification and validation of the SCARLET system, which is a possible solution to the complex challenge of deblending LSST data in the operational era. In addition, this sprint was a valuable opportunity for the development team to experiment with new methods of organizing and scheduling work.

- The Science Pipelines team made significant computational improvements in both the afw::table system, which is used pervasively for tabular data throughout the LSST codebase, and the algorithms being used to mitigate differential chromatic refraction (DCR). These were accompanied by the completion of the "GenericMap" data structure, which will underlie upcoming improvements to LSST's representation of image data. The Pipelines team also standardized on Jointcal as part of the default processing pipeline applied to Hyper Suprime-Cam (HSC) data during system verification, replacing the (legacy) meas_mosaic. This represents a significant vote of confidence in the Jointcal system.
- A series of upgrades were made to the Alert Distribution system, focusing on more rigorous versioning of the alert schema and on providing user-friendly APIs to enable DM developers and external stakeholders to interact with LSST alerts.
- Using simulated M1M3 telemetry, the team demonstrated that the DM engineering facilities database (DM-EFD) architecture is capable of keeping up with the full, unaggregated stream of topics received from the SAL to the data being ingested in a remote InfluxDB deployment. This opens up the possibility of using a single architecture for the EFD across subsystems.
- Subsystem Scientist L. Guy represented DM as an invited speaker at the 20-23 LSST@Asia meeting. She gave an overview of the DM subsystem and a demonstration of the LSP.
- Several team members participated in the International Virtual Observatory Alliance (IVOA) Interoperability meeting the week of 12 May. Big Data Architect C. Banek was appointed vice-chair of the IVOA Grid and Web Services Working Group, and DM Systems Engineer T. Jenness helped coordinate Data Curation and Preservation Interest Group meetings in his role as that group's vice-chair. In addition, DM presented various aspects LSP development and deployment.

Education and Public Outreach (EPO)

- The Education and Public Outreach (EPO) team completed work on the *Exploding Stars* and *A Window to the Stars* web-based formal education investigations. The team also began planning for Alert Stream web displays.
- Head of EPO A. Bauer planned detailed work to be done in fiscal year 2020.
- In preparation for sharing video resources with science collaborations members, A. Bauer created an inventory of video resources produced by EPO, including 20 full-dome planetarium resources and documentation.
- The team began reviewing EPO documentation in preparation for the upcoming Joint Status Review.
- Science Writer K. Metzger has begun storyboarding a video developed from the interviews collected during the LSST2018 Project and Community Workshop's Storytime Domain. The new video will debut at LSST2019.

- Blake Mason began work as EPO's Senior Web Developer, and developer Abby Yacoe left the project.

Change Request Status

This period the following change requests (LCRs) were initiated, approved or rejected.

LCR #	Title	Status
n/a	Update GIS-Dome ICD	Rejected
1788	Modify LSE-68 to Reflect Actual Interface	Submitted
1789	EPO Revised Staffing Plan	Submitted
1793	Move up Calibration Screen EIE Milestone	Submitted
1803	Baseline Additional M1M3 Thermal Systems Effort	Submitted
1805	CRTM-2 Non-Conformance	Submitted
1806	Update Ship Dates for Remaining Critical Items	Submitted
1807	L1-L2 Assembly As-Built Baffle Non-Conformance	Submitted
1808	Additional Budget for Dome Construction Crane	Submitted
1809	Update of Master Security Policy	Submitted
1813	RTM19 Non-Conformance Waiver	Submitted
1823	Move 1.04C.15.07 End Date to August 2020	Submitted
1824	Move Up completed Long Haul Network Milestones	Submitted
1825	NCSA May 2019 Schedule Update	Submitted