	Document #	Status:
Large Synoptic Survey Telescope	**LCA-30-G**	LSST Camera APPROVED Effective Date 17 July 2018
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	Subsystem/Office: System Engineering	

Document Title:

LSST Camera Risk Registry

Purpose

This document collects the bottoms-up risk elements of all LSST Camera subsystems, and compiles them into a single log. It includes all retired and open risks.

Definitions

Anal	Analysis
CB&M	Camera Body and Mechanisms subsystem
CCS	Camera Control System subsystem
CoDR	Conceptual Design Review
Crnr Rft, Crft	Corner Raft subsystem
Cryo	Cryostat subsystem
D&D	Design and development phase work
DAQ	Data Acquisition subsystem
ETU	Engineering test unit, breadboard, or other mock-up
LSST	Large Synoptic Survey Telescope
Mng	Management
Opt	Optics subsystem
PDR	Preliminary Design Review
Sci Rft, Srft	Science Raft subsystem
SE	System Engineering
SS	Subsystem

References

Change Log

	Revision G
17-Jul-18	Release per LCN-2106.
16-May-18	Post May RRB
15-May-18	Updated for May RRB
18-Apr-18	Post April RRB
17-Apr-18	Updated for April RRB
21-Mar-18	Post March RRB
20-Mar-18	Updated for March RRB
21-Feb-18	Post February RRB
20-Feb-18	Updated for February RRB
16-Jan-18	Post January RRB updates
28-Nov-17	Updated for Nov RRB
24-Oct-17	Updated post RRB to incorporate RRB actions. Ready for Monte Carlo.
17-Oct-17	Updated for Oct RRB
13-Sep-17	updated after Sept RRB
12-Sep-17	updated for Sept RRB
20-Jul-17	Updated post July RRB
18-Jul-17	Updated for July RRB
21-Jun-17	Updated post June RRB
20-Jun-17	Updated for June RRB
16-May-17	Updated for May RRB
19-Apr-17	Updated Post Risk Board Meeting
18-Apr-17	Updated for April RRB
17-Mar-17	Updated for March 18 RRB
14-Feb-17	Updated for Feb 15 RRB
20-Jan-17	RRB actions involving top 10 risks implemented
18-Jan-17	Updated for Jan 18 RRB
29-Nov-16	Updated for post Nov RRB Monte Carlo, added "accepted" as a risk status
16-Nov-16	Updated for Nov 16 2016 RRB
28-Oct-16	CCD risks moved to separate sheet
18-Oct-16	Updated for October 2016 RRB
21-Sep-16	Updated for 21 Sept RRB
8-Aug-16	Updated for 8 Aug RRB

26-Jul-16	Updated lein list and macro, Camwide corrections
20-Jul-16	Updated CAM-045, SRFT-070 and CAM-018 per discussions with Nadine Kurita
12-Jul-16	Extended equations for probabilistic assessment of total risk
21-Jun-16	Updated for June inputs, no RRB
17-May-16	Updated for May RRB
20-Apr-16	Updated for April RRB
16-Mar-16	Updated for March RRB
16-Feb-16	updated for Feb RRB
28-Jan-16	Updated unfunded costs as a result of the Jan 28 CMC.
20-Jan-16	Merged Sys Int and corner raft post RRB
19-Jan-16	Completed merge for Jan RRB
15-Jan-16	Merge Optics updates for Jan RRB
2-Dec-15	Included Science Raft and SysInt updates for Dec RRB
1-Dec-15	Updated for December Risk Board Meeting
27-Oct-15	Updated for October Risk Board Meeting
23-Sep-15	Updated Post Risk Board Meeting
22-Sep-15	Updated for Risk Board meeting
26-Aug-15	Updated for Risk Board meeting
22-Jul-15	Corrected typo in CAM-010
17-Jul-15	Updated with actions from risk board meeting and finalized for CD-3
11-Jul-15	Removed can be targeted column, partial update post risk board meeting
7-Jul-15	Updated for Risk Board meeting
21-Jun-15	Updated risk OPT-21
8-Jun-15	Updated Post Risk Board Meeting
5-Jun-15	Updated for Risk Board meeting
27-May-15	Updated for Risk Board meeting
21-Apr-15	Updated for Risk Board meeting
24-Mar-15	Updated for Risk Board meeting
17-Feb-15	Updated for Risk Board meeting
10-Dec-14	Updated for Risk Board meeting
14-Oct-14	Updated for Risk Board meeting
19-Sep-14	Updated cryostat obsolete risk ratings, changed sort and added subsystem statistics
12-Sep-14	Updated after Risk Board Meeting
11-Sep-14	Updated for Risk Board meeting
20-Aug-14	Updated for Risk Board meeting
11-Aug-14	Updated for Risk Board meeting
15-Jul-14	Updated for Risk Board meeting
21-May-14	Updated for Risk Board meeting
	Revision F
22-Apr-14	Merged Sci raft and cryostat risks.Captured for CD3a
14-Apr-14	updated revision list
11-Apr-14	Merged with Science Raft updates
11-Apr-14	Remerged with optics and I&T changes
9-Apr-14	April 9 merge for RRB
17-Mar-14	updated residual schedule for science raft and cryostat
14-Mar-14	Corner raft update for wbs, optics added 2 risks
14-Mar-14	After science raft update for wbs and for unfunded mitigation costs
12-Mar-14	Feb 12 merge for RRB
13-Feb-14	Feb 13 merge
12-Feb-14	Feb 12 merge
26-Jan-14	refreshed watch list
26-Jan-14	Updated risk ranking algorithm
21-Nov-13	Corrected previous upload. One of the merge files was stale
21-Nov-13	Adds science raft post mitigation cost update
14-Nov-13	Merged ELX risk
14-Nov-13	November 14 merge
30-Oct-13	Reformatted
3-Oct-13	Merged risk sheet as of 3 Oct.
	Revision E
21-Oct-11	Updated risk values for CCD yield (ID Srft-002) and Raft Alignment (ID Srft-003). Corrected Mitigation title and description for Software crossbar scaling (ID DAQ-004). Status set to "Review"
	Revision D
20-Oct-11	Revised risk registry for CD-1 Review; set status to "Review" Updated Crossbar and refrigeration. Normalized with the Risk Review Board the top 20 rankings, and re-ranked the ones with common scoring.

	Revision C
14-Oct-11	>Finalized risk registry for CD-1 Review; set status to "Review"
3-Oct-11	>Added post-mitigation cost and schedule contingency assessment and contingent cost/delay analysis; met with all subsystems and updated entire risk registry to current risk levels; added columns to track original risk level for history; re-arranged entries to match reporting plans
10-Sep-11	>Started rev C to capture changes in Risk Mng Plan to include cost and schedule contingency analysis; added columns to capture input for analysis and tie in risks to WBS
	Revision B
19-May-11	>Added updates from J. Langton for Cryostat risks
13-Apr-11	>Changes added at Risk Review Board
8-Apr-11	>Added summary statistics for RRB prep
6-Apr-11	>Added SE-011 on exposure timing and cadence
31-Mar-11	>Re-organized by risk score to show top risks
31-Mar-11	>Updated DAQ risks with Mike Huffer; input further updates on Sci Raft from Paul O'Connor and Rick Van Berg; Martin Nordby added Cryo mech updates directly into registry
28-Mar-11	>Added camera-level risks from Nadine Kurita; these cover management and I&T risks
28-Mar-11	>Added Corner Raft and Optics updates from Vincent Riot; included updates on Optcis mechanical risks from Martin Nordby
28-Mar-11	>Added Sci Raft updates from Rick Van Berg; still need updates from Paul O'Connor and John Oliver
28-Mar-11	>Added updates from John Ku/Pierre Karst for CB&M, and Jon Thaler/Rick Van Berg for CCS
9-Mar-11	>Renamed the Risk Registry; started rev B
	Revision A
25-Mar-10	>Added data validation drop-down menus in select columns; split up copes of the sheet into subsystem worksheet for modifying
22-Mar-10	Brought 'Risk Analysis Methodology' table into accordance with latest Risk Management Plan analysis details; fixed formulae and conditional formatting in 'Risk List'; cleaned up headers on table; cleaned up 'Risk Matrix' and emptied it out;
16-Mar-10	>Completely revised, re-formatted, and new number assigned
1-Dec-09	>Initial integration of subsystem assessments (leveling) after review by Systems Engineering and Project Management (Observatory & Camera). Integrated full list of current & retired camera risks into Observatory risk format
26-Aug-09	>Checked out drawing number and formatted Risk List to be a configuration-controlled document.

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Cam	3.01	CAM-040	Standing Army Costs 6 months	If the camera is late on elements, THEN standing army costs will be needed to complete the project	Riot	Mng	15-Jul-15	4	4	4	1	14.7	Moderate	Study	Standing Army	1) Manage contingency relative to float (ONGOING) 2) review opportunity to reduce standing army costs. The main mitigation is to complete I&T work currently on hold or delayed with current manpower to mitigate standing army costs (IN PROGRESS)		Working	5/2018: Mitigation in I&T successful for the heat exchanger delays. 4/2018: no update. risk is still high. 3/2018: camera project delayed by one month and cost accounted in EAC for one month delay. Risk adjusted to reflect that. 07/2017: standing army mitigations reviewed by project in depth to cover I&T delays to to late elements. 04/2017: residual risk increased as mitigation are not very effective 03/2017: 10 major activity flows are within 30 days of the critical path. The probability of delays is increased. 7/2015: Project currently has 24 months of float. 5/2015: Project has 22 months of float. 10/2014: Entry. Note these assume standing army cost for specific sub-systems to finish work and not I&T (captured elsewhere).	CD-4	6/1/2020	10/1/2018	4	4	4	1	14.7	Moderate	$600	$1,500	$2,400	05/2018: no change 04/2018: no changes 03/2018: nominal reduced to 5 month due to enacted delay. $400K/month standing army worst case (Manageneent/SI/I&T). 300k standing army cost nominal by recovering some late activities.	3.0	5.0	6.0		25%	67%	$375	$1,005	$926	690.00	1.25	3.35	4.02
CB&M	3.06.01.02	CBM-50	Camera Housing Fabrication	If the dimensional requirements cannot be achieved with the Camera Housing will not fit in the assigned envelope.	Oriunno	Fab	16-Apr-18	5	2	4	1	13.3	Moderate	Study	Fabrication Process options	1.Develop alternative fabrication process with the vendor aimed to correct the errors 2. Procure raw material. 3. Adapt the design to an eventual alternative forging process		Working	5/2018: 2 heat treatments were completed and brought the performance closer to specification. Working with vendir on meetings to assess whether the remaining non-conformance can be machined out. 4/2018: Working with the vendor on alternative fabrication process to correct the errors	Camera Body Delivery	7/15/2018	4/16/2018	2	2	4	1	5.3	Minor	$17	$50	$150	Spend more engineering resource than expected to folow up the contract	2.0	3.0	6.0		1%	5%	$1	$3	$11	1.84	0.03	0.15	0.30
Opt	3.05.02	Opt-021	Single filter coating witness sample vendor	IF the single witness sample vendor selected does not meet specifications in their planned iterations THEN the cost and/or schedule and/or performance may be impacted.	Wolfe	ETU	15-May-18	4	3	1	4	12.7	Moderate	Proto	Work with science team and vendor on specifications updates	Per Opt-001, a phase 3 R&D is planned to generate a set to witness samples (down-selected with one vendor). If that vendor fails to meet requirements for all 6 filters, there is not enough time in the schedule to redo a development contract at another vendor. The current primary mitigation is to work with the science team and the vendor to optimize specifications to better match vendor capabilities. The specifications as given currently must be vendor-neutral and not tailored to the capabilities of any one vendor. After the contract is awarded, upon vendor feedback, it may be helpful to slightly tune the requirements to allow vendor to meet the requirements more easily, if such changes can be made without changing the science function of the filter(s). Project could decide to ship filters directly to summit which would give additional ~2 years in the schedule.		Working	5/2018 Vendor has completed 4 of the 6 witness bands. To this point all have been usable, but with minor deviations from requirements. '3/2018: Vendor has completed 3 of the 6 witness samples. Currently working y-band witness sample and several mnths behind schedule. '10/2017: Based on Sept risk board meeting, updated current cost to 3 from 4. Vendor progress good to date and cost level of 3 is more appropriate. '6/2017: Vendor is nearing the end of the development phase. r-band is very close, but u-band needs more work. Plan to start r-band witness samples within 1 month. '3/2017: Vendor is completing several trial runs and preparing for witness sample runs. Current risk exposure is still high. '5/2016 Contact awarded to vendor and demonstration phase expected to be completed in May 2017. '7/2015 Increased probability and impact based on CD-3 Director's Review discussions and science team comments '5/2015 Added mitigation option of delivery to summit versus I&T to provide schedule float. 3/2015 Several vendors will be considered for demonstration phase. '-PST is workign on understanding science impact for various filters possible issues		12/1/2017	12/1/2017	3	3	1	3	8.5	Minor	$200	$1,200	$1,500	Cost for demonstration phase budgeted at $1200K based on ROM estimates.	3.0	6.0	6.0	The mitigation is to deliver filters after the camera delivery date. The schedule delay is overridden to allow the Monte Carlo analysis to estimate impact to KPP verification.	5%	25%	$60	$300	$423	162.50	0.30	1.50	1.50
Cryo	3.06.04.06	Cryo-072	Cryo Refrigeration system degraded process power capacity	If the Cryo system shows slow degradation of cooling capacity, THEN the camera may not be able to meet system requirements	Callen			4	3	2	3	12.7	Moderate			1 - Changing filter dryer every three months. 2 - If related moisture in the line, then, changing filter dryer every three months. 3 - If schedule and budget permit, perform additional long term running to obtain additional data for troubleshooting		Working	5/2018: filter dryer being assembled (needed to prevent degardation due to moisture). 7/2017: Cryo system long term running data shows degradation. We know there are moisture in the system. Some strategies includes 1) periodic downtime to stop and start the system possibly every three months. This would introduce additional thermal cycling; Addition of recharging or flushing may be required. Cost to replace compressor at $20k each x6, multiply by unknown number of re-occurance.			5/1/2017	3	2	2	2	7.0	Minor	$30	$200	$200		0.5	1.0	1.5		5%	25%	$10	$50	$67	25.75	0.05	0.25	0.38
Cam	3.01	CAM-049	ITL sensor integrated performance	IF ITL sensors cannot be operated when integrated in a raft with adequate performance THEN the project will not be able to deliver the camera successfully	Riot	Mng	6-Jan-18	4	3	2	3	12.7	Moderate		Re-direct resources	1) Create a tiger team to review this problem (DONE) 2) Appoint deputy chief electrical engineer full time to coordinate all effort related to the issue. This involves delaying corner raft activities. (DONE) 3) Develop a backup TS7 dewar at BNL dedicated to ITL raft testing (DONE) 4) Develop a simulation model of the ITL sensors to guide investiagtion and test parameter space (DONE) 5) conduct testing at IN2P3 on sensors+flex cables (DONE) 6) Measure Bias level at TS3 with warm sensors and only assemble RTMs with low bias, which has been seen to correlse with low noise sensitivity (DONE) 7) Plan to use both Science and Reserve grade ITL sensors (will need to mitigate poor HCTE on Reserve grade sensors) 8) Use the 30 SLIN3 e2v sensors for RTMs (PLANNED) 9) Use 8 e2v sensors originally planned for corner raft wavefront sensors for science rafts and replace these with ITL sensors (2/23/2018 decision point - DONE) 10) Prepare existing or procure new RTM baseplates for additional e2v RTMs (3/1 decision point - DONE) 11) Understand root cause and rebuild REBs to lower injected noise (DONE) 12) Understand and document relationship between noise performance and camera readout time; discuss options with upper level LSST Project management (DONE) 13) Upgrade The REB5 for remaining ITL (IN PROGRESS)		Working	5/2018: LPM-262 and LCA-16456 completed show it is acceptable to use degraded sensors. Risk reduced 2/2018: Risk update. effect is now known to be intrinsic to the CCDs. Mitigation is to improve REB and work with project regarding performanc eimpact of using sensors as is 1/2018: Risk creation due to lack of success in Making RTM8 work. Current exposure assumes purchasing e2v sensors to reach threshold KPP. The goal of the mitigations is to limit cost exposure to electronics only by doing more testing to identify the problems. Sensors perform as they should when driven by the ARCON controller (testing by vendor & LSST) so nominally one would expect to be able to make them work with different electronics, such as the REB5 boards coupled to the LSST DAQ.	CD-4	4/1/2018	1/1/2018	3	3	2	3	9.5	Minor	$0	$201	$225	5/2018: ITL sensors are in sufficent quantities to be within the LPM-262 distribution. Cost is retrofitting 6 rafts with updated electronics with labor associated for upgrades of $75K. Max Cost is 150K/month standing army at BNL to retrofit raft with new sensors upon testing. 4/2018: 170 sensors are needed for threshold KPP. 120 sensors are currently budgeted from e2v and 36 + 14 reserve ITL have been screened to meet noise requirements. ~15 more sensors would be needed to meet the threshold KPPs. E2v sensor cost is ~$110K/sensor. Max cost is to reach the 197 sensor count with e2v and in-hand ITL. Mid-range cost is to	0.0	1.0	1.5	delays understanding or retrofitting raft to match the LPM-262 distribution	5%	25%	$10	$50	$67	25.73	0.05	0.25	0.38
Cryo	3.06.04.06	Cryo-071	Down time requirements for the camera	IF the refrigeration system processing drives maintenance durations over the camera allocations, THEN the throughput for the camera operation will be impacted.	Callen			5	2	1	3	11.7	Moderate			1- 3. Establish and validate operations and maintenance requirements and procedures. 2- If project budget permits, then add equipment to test and validate fault and recovery scenarios.		Working	5/2018: filter dryer being assembled (preventative maintenance before assembly) 7/2017: Refrigeration system may significant down time beyond the operational annual down time allotment on a rare occassion based on other subsystem maintenance. System engineers are evaluating downtime stack up of various subsystem. 6/2017: This risk is created based ont the I&T refrigeration FDR action items.			Post CD-4	5	1	1	3	9.2	Minor	$0	$10	$30	This risk is created based on the action items from the I&T Refrigeration system FDR in May. The observatory team will create a similar high risk to accept the risk that the refrigeration system will not meet the downtime requirement.	0.0	0.5	0.5		67%	100%	$7	$10	$7	9.74	0.34	0.50	0.50
I&T	3.08.03	IT-014	Cryostat Deliverables Schedule	IF the cryostat assembly (and/or associated parts) are delayed in their availability to I&T THEN mechanical integration of RAFT towers into the cryostat will be delayed.	Reil	I&T	14/5/2018	4	3	3	1	11.3	Moderate	Study	Cryostat I&T coordination	1) Mockup cryostat to be developed to optimize time needed for raft tower integration verification (COMPLETED).		Hold	5/2018 - Probability reduced and status changed to HOLD as delivery date nears. 7/2017 - EAC work with cryostat team indicated this schedule is especially tight. 6/2016 - Risk identified - Coordination has been underway for a while.	6/1/2018		6/8/2018	4	3	3	1	11.3	Moderate	$150	$200	$300	Standing army cost on raft integration for 2 month delay.	1.5	2.0	3.0	Schedule delay of 2 months	25%	67%	$50	$134	$127	95.83	0.50	1.34	2.01
I&T	3.08.03	IT-015	Refrigeration Deliverables Schedule	IF the I&T refrigeration system is delayed THEN Science Raft integration cannot proceed as scheduled.	Reil	I&T	14/5/2018	4	3	3	1	11.3	Moderate	Study	Refrigeration I&T coordination	1) Coordinated refrigeration acceptance testing prior to I&T delivery to ensure system operation are understood early (PLANNED/IN-PROGRESS) 2) Ensure de-integration risk is reduced by practising with the mockup cryostat (PLANNED/IN-PROGRESS) 3) Refirgeration team to increase oversight and add visits (PLANNED) 4) I&T schedule to be shuffled to accomodate later delivery if possible. 5) All science rafts could be integrated at once at considerable risk to alleviate schedule.		Working	5/2018 - delays in HX delivery has prompted a shuffle in activities in the I&T schedule to accommodate as outlined in BCR-xxx. 2/2017 - EAC work with cryostat team indicates schedule is tight. 06/2016 - Risk identified - Coordination has been underway for a while	11/1/2018		11/1/2017	4	3	3	1	11.3	Moderate	$150	$200	$300	Standing army cost on raft integration for 2 month delay.	1.5	2.0	3.0	Schedule delay of 2 months	25%	67%	$50	$134	$127	95.83	0.50	1.34	2.01
Opt	3.05	Opt-039	Filter delivery	IF Filters are delayed during production, THEN schedule and cost impacts will be incurred.	Wolfe	Fab	19-Mar-18	4	3	3	1	11.3	Moderate	Study	Vendor Oversight	7/2016: Current float to I&T need date is 198 days per P6. Additional mitigation is to deliver delayed filters to the summit, separate from the camera delivery. 2015: Current P6 schedule has 40 days of float on remaining 5 filters delivered to I&T. Typically optics fabrications take longer than planned. Vendors will be monitored closely to mitigate potential schedule delays.		Working	3/2018: Vendor has been delayed due to technical difficulties in manufacturing. r-band filter is nearing the 1st TWE test. 7/2017: All filters have been shaped and r-band filter is in grinding phase. 1/2016: working through the procurment award for Filter Optic Fabrication. 7/2016 Changed cost impact from 2 to 3 to match current residual cost estimate. Reduced schedule impact from 4 to 3 due to current float.		1/1/2020	2/1/2018	4	2	3	1	9.3	Minor	$30	$100	$200	Nov 2016 EAC realized some of the risk and the post-mitigation cost has been reduced. For remaining, assume handoff between fabrication and coating vendors causes delay. Chamber time alocated $30K plus $30K for misc contract delays. Assume additional manpower required to support contracts due to delays $40K. For a total of $100K	1.5	3.0	3.0	Assume fabrication vendors has delay of 3 months beound current float.	25%	67%	$25	$67	$66	48.30	0.75	2.01	2.01

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																				
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
I&T	3.08.03	IT-010	Camera Level Noise	IF additional noise appears during integration THEN I&T will need to diagnose the source of the noise and support mitigation strategies	Bond	I&T	1-Jul-16	4	2	2	3	10.7	Moderate	Study	Noise testing	1) Budget time/effort in Cryostat level I&T, when the first two rafts are integrated, for noise study & mitigation. See ITC14774. 2) Additional shielding options are being explored		Hold	6/2015: Moved status to holding. Will hold until raft testing is completed. 5/2015: I&T will need to be prepared to evaluate noise levels in multi-raft system. If noise in excess of requirement is found a working group between I&T and SR will need to form quickly to find a solution. Tied to ITC14774. 4/2018: Grounding strategies are being refined, and additional shielding options are being explored.	ITC00450		9/1/2018	3	2	2	3	8.0	Minor	$30	$100	$200		0.5	1.0	1.5		5%	25%	$5	$25	$42	15.75	0.05	0.25	0.38
SE	3.02.01	SE-038	Incomplete development of verification plans	IF subsystem verification plans are not adequately thought out and executed, THEN delivered hardware may not function as required at camera I&T, or the I&T schedule may be delayed	Mendez	I&T	11-May-18	4	2	3	2	10.7	Moderate	Study	Flesh out verification plans early	1. Develop verification plans for all reqs early, to capture all needed verif work; 2. Lay out work schedule to adequately capture the time to verify reqs per the plan;		Working	5/2018: initiated risk; working with subsystems to develop plans		7/1/2019	2/1/2020	2	1	1	1	2.3	Insignificant	$0	$30	$30		0.0	0.5	0.5		1%	5%	$0	$2	$4	0.75	0.01	0.03	0.03
Opt	3.05.03	Opt-024	L3 Position	IF the L3 frame does not hold the optic in place to required levels THEN the image quality may suffer	Wolfe	I&T	15-May-18	3	3	3	3	10.5	Moderate	Anal	Evaluate and update design	1 - Evelaute performace on the test window (IN PROGRESS) L3 frame to be evaluated and updated by design-build vendor. Ensuring optic postion stability to be critcal part of design effot		Working	5/2018: Thermal cycles showed motion at the limits of the requirement Additional analysis being done. 6/2015: Contract awarded 3/2015: FDR planned for Sept 2015. RFP to be released late calendar year 14		6/17/2017	3/1/2019	1	3	3	3	3.5	Insignificant	$200	$250	$1,500		1.5	2.0	3.0		0%	1%	$0	$3	$35	2.25	0.00	0.02	0.03
I&T	3.08.03	IT-006	Raft Tower Collision	IF rafts/sensors collide with neighbors during integration, THEN additional sensors/rafts would need to be procured and assembled	Roodman	I&T	14/5/2018	3	3	3	3	10.5	Moderate	Proto	Pathfinder units	1) Manufacture of a mockup cryostat for integration test runs (COMPLETED). 2) Manufacture of mechanical RTMs for integration test runs (COMPLETED). 3) Scheduled use of mechanical RTMs in Mockup cryostat for Integration Gantry Verification (IN PROGRESS) 4) plan to use ETU1 and ETU2 for integration test runs (PLANNED)		Working	4/2018: Integration Gantry Verification work under way. 2/2018: MTR and Mockup completion. 9/2017: MTR and Mockup construction begins. 4/2015: Test Rafts and Eng Grade RTM's are budgeted and planned. 10/2013: risk captured	6/1/2019		6/1/2019	2	3	3	3	7.0	Minor	$200	$700	$1,500	Cost of damaged RTM repair.	1.5	2.0	3.0	Time to repair damaged RTM	1%	5%	$7	$35	$135	22.50	0.02	0.10	0.15
I&T	3.08.02	IT-023	Sustaining Engineering	IF the current program plans do not maintain personnel with adequate technical knowledge, THEN the technical staff may not be available to support issues that arise during I&T.	Reil	I&T	1-Aug-16	4	3	2	1	10.0	Minor	Study	I&T Planning	1) Identify key personnel and plans for maintaining their availablity to I&T. 2) Add sustaining engineering LOE activities in I&T budget (some IN PLACE, some has been de-scoped in the FY18 EAC)		Working	11/2017: Some sustaining engineering LOE has been reduced to maintain budget. Some LOE remains in the plan. 8/2016: Initial entry. There has been budget in I&T for sustaining engineering, but more work needs to happen to ensure we can transition people onto I&T and/or early operations. In some cases we need to develop agreements with the lab to maintain some level of participation as needs arise.	CD-4		9/1/2018	4	3	2	1	10.0	Minor	$200	$900	$2,000	Cost of LOE for sustaining engineering covers 2FTE for FY19/FY20 (1.5 year).	0.5	1.5	3.0	delay due to staff unavailability	25%	67%	$225	$603	$617	444.67	0.38	1.01	2.01
Cam	3.01	CAM-026	Procurement delays	IF hardware or subcontract procurements are delayed or held up, THEN schedule delays could affect L2 delivery milestones (Note: optics, grid, RSA baseplate and sensors are excluded, and itemized separately)	Riot	Procure	15-Jul-15	4	3	2	1	10.0	Minor	Study	Trend procurement performance	1) Track and trend procurement performance in PMCS (ONGOING) 2) shift procurements to other institutions within collaboration to bypass problem areas (DONE all procurement mostly in place)		Working	5/2018: all major procurements in place. Still some issues with key components such as camera body housing, heat exchanger and shutter blade likely 12/2017: shutter blade RFP is out for bid 11/2017: heat exchanger and compressor chassis procurement placed. Shutter blade only major procurement remaining. 7/2017: minor procurement (including camera body back-flange and camera body housing) have been placed. Vendors are being monitored for progress. 8/2016: Watch cryoplate and housing procurements 5/2016: schedule delays assessment reduced to less than 3 month. Procurement on the critical path are captured separately and procurement covered under this risk have less schedule impact. 7/2015: itemized schedule delay for the RSA baseplate 4/9/2014: Refined risk by milestone levels. Maintain minimum 120 days of float on all non sensor L4 activities. Start procurements early. 9/2011: P6 schedule completed using published procurement process times and vendor quotes for lead times on major items. 4/2011:Incorporating procurements explicitly in project schedule for tracking; procure plan awats baselining with the rest of the schedule	CD-4 Review	6/1/2020	10/1/2018	3	3	3	1	8.5	Minor	$420	$840	$2,100	05/2018: no hange 04/2018: no change 03/2018: reduce delay assumption to 2 months due to delay to June 15 delivery and 5 month not on CP. $420 /mo standing army costs FY19 full camera Items are not on critical path. Assume 3 months of degradation to CP and up to 6 months in cost not on CP	1.0	2.0	5.0		5%	25%	$42	$210	$391	147.00	0.10	0.50	1.25
Opt	3.05.02	Opt-025	Filter Coating Failure	IF a filter coating run fails THEN the filter coating will not meet all specifications	Wolfe	Procure	16-Jun-17	3	2	4	3	10.0	Minor	Proto	Monitor design and vendor preparation	Vendor will demonstrate design tolerance to failure and preparedness for coating. All coatings will be demonstrated prior to deposition on substrates. Additional schedule could be made available by camera project if shipped directly to summit.		Working	6/2017: Vendor is currently completing coating runs and collecting information to help assess this risk. 6/5/2015: Preparation of RFP includes production phase and will include appropriate QA Fitler development contract planning is well underway		11/1/2019	2/1/2018	2	2	4	3	6.7	Minor	$30	$200	$200	Assumes 1 filter run fails and needs replacement ($200K)	3.0	6.0	6.0		1%	5%	$2	$10	$30	5.15	0.06	0.30	0.30
Opt	3.05.02	Opt-026	Filter Breaks during Fabrication	IF the substrating is damaged during grinding (or later phase) THEN the substrate will have to be replaced	Wolfe	Procure	16-Jun-17	3	2	4	3	10.0	Minor	Anal	Vendor Oversight	Monitor vendor setups and processes. Ensure proper equipment is in place and all actions are taken according to agreed upon work and handling protocols		Working	Will be part of contract oversight process 7/2015: discussed controls with potential vendors 8/2015: updated risk title based on Filter fabrication procurement review 6/2017: Vendor is grinding r-filter and shaping all others.		12/1/2018	1/1/2017	2	2	4	3	6.7	Minor	$30	$120	$200	Covers cost of blank and other delay impacts	3.0	6.0	6.0		1%	5%	$1	$6	$21	3.55	0.06	0.30	0.30
Cryo	3.06.05	Cryo-058	UT Subsystem Interface	IF the interface design information from other subsystems are not provided to the UT subsystem on schedule, THEN the UT will need more time and resources to modify and completed the UT integration design.	Callen			4	3	2	1	10.0	Minor			1. Add NEED milestones and link to other subsystemsi n the schedule. 2. Regular interface meetings with other subsystems.		Working	1/2018: Mock-up workshop held in October 2018 and uncovered several subsystem interface issues. Cost to mitigate these issues are substantiated in the 2018 EAC. 7/2017: Held a mock-up review meeting with other subsystemin June. Mock-up parts in fabrication. Assembly workstation in place ready to receive part and start assembling.				3	2	2	1	6.0	Minor	$30	$50	$200		0.5	1.0	1.5		5%	25%	$3	$13	$30	10.75	0.05	0.25	0.38
CCS	3.07.02	CCS-010	Late scope changes	IF subsystems come with late changes to CCS interface scope, THEN CCS-provided software modifications will be required	Johnson	Fab	22-May-15	5	2	2	1	10.0	Minor	Study	Develop and review ICD's	Use ICD's to collect required functionality. Hold regular meetings with subsystem developers.		Working	11/2016 - mitigation is to review the relevant ICDs by end of year. 10/2016 -- several subsystems have come with requests for support beyond the original scope of the ICDs. Part of this additional scope has been handled with BCR-036. The possibility of more subsystems doing likewise is probably increase We have developed ICDs with all subsystems, and continue to work closely with each camera subsystem. 5/15/2018 We continue to actively discuss increased scope with each subsystem. Some BCRs have already been approved to address more significant issues, and we attempt to cover smaller requests under existing planned work packages, but the risk of continued scope creep is still there, and the current risk assessment seems realistic.	PSR		11/20/2018	4	2	1	1	6.7	Minor	$30	$150	$400		0.0	0.0	0.5	Early testing would catch problems before they cause a schedule problem	25%	67%	$38	$101	$112	78.97	0.00	0.00	0.34
Cryo	3.06.04.04	Cryo-044	Grid Damage	IF the Grid is damaged during assembly at SLAC THEN it will need repair or replacement	Callen	Fab	18-Oct-16	3	3	3	2	9.5	Minor	Study	Handling, tooling procedures	1-Develop procedures and train operators. Complete. 2-Revise cleaning procedures to minimize risk. Complete, reviewed and revised procedures and process, including new tooling and tanks		Working	7/2017: Secured grid in gated storage area. Trained personnel in handling procedure. 3/2017: Grid is due to arrive at SLAC 3/16. MRR is scheduled for 3/23. 10/2016: Initial entry	CD-4	3/1/2018	6/1/2017	2	2	3	2	5.3	Minor	$30	$150	$200		1.5	3.0	3.0		1%	5%	$2	$8	$24	4.15	0.03	0.15	0.15
I&T	3.08.06	IT-030	Camera housing fit-up to back flange	IF the camera housing does not fit well with the back flange, THEN the camera I&T schedule could be delayed during re-work	Bond	I&T	14-Jun-17	3	3	3	2	9.5	Minor	Anal	Accept risk	1. Work with CB&P to better understand possible fit-up concerns and recovery options. 2. Prototyping, fixturing, and other intermediate options to address possible fit-up problems could be implemented, if cost is considered warranted		Hold	6/2017: Added risk to capture the late delivery of the camera housing, preventing early fit-checks with the back flange prior to it going to Paris for carousel integration			8/1/2018	3	3	3	2	9.5	Minor	$200	$200	$1,500		1.5	3.0	3.0		5%	25%	$10	$50	$180	62.50	0.15	0.75	0.75
CCS	3.07.01	CCS-026	Contributed Labor	IF the CCS relies on substantial amounts of contributed labor and if that contributed labor fails to materialize, fails to deliver the expected software, or delivers software that does not meet the requirements THEN additional on-project manpower may be needed to compensate.	Johnson	Fab	20-Jul-17	3	3	4	1	9.5	Minor	Study	Ensure adequate management of contributed labor	1-Ensure that we keep track of the expected deliverables from all contibuted labor by tracking deliverables in the CCS WBS work items, arranging necessary training and arranging regular face to face meetings and teleconferences, tracking status of deliverables in monthly CCS status reports. 2-Contact collaboration institutions and groups (UK, IN2P3) to expand the pool of contributed labor		Working	11/1/16 We are currently planning to bring onboard new UK (Oxford) and French (Grenoble) labor. We will arrange a CCS turorial during the next CCS workshop in Paris. 5/15/17 We are in the process of developing a SOW with Oxford to cover some work on time synchronization (PTP) and timing requirements verifycation, plus contributions to the OCS/CCS bridge. In addition we have identified additional French manpower and are in the process of assigning tasks to them. Ian Shipsey is looking into the possibility of getting additional UK manpower. 10/17/2017 Contributed labor from Oxford now actively working on the project. Additional contributed labor from Santa Cruz and France being trained. 5/15/2018 We have succeeded in bring on board additional contributed labor from Oxford and Santa Cruz, and expect Homer Neal to return from BNL in June. However we have recently lost one core developer from the team in Paris, and do not expect to be able to hire a replacement until November. The current risk level remains appropriate.	PSR		7/1/2017	3	3	3	1	8.5	Minor	$200	$300	$1,500		1.5	2.0	3.0	2 months assuming impact on the gantry and the BOT	5%	25%	$15	$75	$203	72.50	0.10	0.50	0.75

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Sci Rft	3.04.01.07	Srft-032	CCD contamination	IF CCD get contaminated during handling THEN defective pixel allocation and throughput performances may not be met.	Wahl	Fab	5-Jun-15	3	3	2	3	9.5	Minor	Anal	Well Defined Process Control & Handling Fixtures	7/7/15 No Change 6/3/15 No Change Implement strict handling procedures in compliance with contamination control plan. Protect sensors with covers at all times when handling, except when actually making measurements or assembling the RSA.		Working	5/15/18 As of May 2018, 14 Rafts have been constructed to date (including 2 ETUs) and all have passed in-process RGA ROR tests, which is good evidence that appropriate process control is in place at BNL. Probability is still identified as "Possible" since there is always a chance it could happen but as long as procedures and protocols are followed, the risk of contamination is unlikely. 10/26/15 The protective covers and handling fixtures work quite well as demonstrated during TS1-3 trials as well as during mock installations on TS4. 6/3/15 Alterations are currently being made to the handling fixtures by B. Kosciuk to even further limit access to the CCDs during handling. Detailed "Work-Flow" and eTravelers include descriptive information for handling during Sensor receipt and acceptance. 10/10/14: Detailed study of integrated CCD contamination has been performed resulting in comfortable margin in relation to target contamination requirements.	End of SR Production	FY2018	3/1/2020	1	1	2	1	1.5	Insignificant	$0	$0	$30	time to clean sensors	0.5	1.0	1.5		0%	1%	$0	$0	$0	0.03	0.00	0.01	0.02
Cryo	3.06.05	Cryo-069	Dynalene leak in Utility Trunk	IF Dynalene leaks inside the utility trunk, THEN it could damage components and requires downtime for repair	Callen			3	3	4	1	9.5	Minor			1 - Use high-integrity fittings and no synthetic hoses in the Utility Trunk 2 - Monitor Dynalene pressure and use a hygrometer in the Utility Trunk to detect a leak		Working					3	2	2	1	6.0	Minor	$30	$150	$200		0.5	1.0	1.5		5%	25%	$8	$38	$54	20.75	0.05	0.25	0.38
Cam	3.01	CAM-006	Communicatio n problems	The camera is a distributed project; IF communication is not adequate, THEN poorly-understood interfaces could lead to delays, cost increases or reduction in performance	Riot	Mng	15-Jul-15	3	3	3	2	9.5	Minor	Study	Formalize Interfaces, Regular Meetings	1) Hold weekly management and technical meetings and manage action items; (IN PROGRESS) 2) Bi-annual camera workshops (DONE until 2015) 3) Define ICDs early (DONE)		Working	5/2018: The bulk of the I&T effort where this risk would realize will not start until June 2018 7/2017: minor changes to interfaces still needed for most of the items are in place for the most part. 9/2011: All interface points defined and draft ICDs in place. 4/2011: On-going; action items tracked at management meetings	CD-4	6/1/2020	6/1/2018	2	3	2	1	5.0	Insignificant	$200	$1,000	$1,500	Guess on cost impact of ICD error discovered late in construction	0.5	0.5	1.5		1%	5%	$10	$50	$169	28.50	0.01	0.03	0.08
Opt	3.05	Opt-037	BBAR coating performance deviation	IF coating run yields a poor performing coating, THEN there will be schedule/cost/performance impacts.	Wolfe	Fab	27-Nov-17	3	3	3	2	9.5	Minor	ETU	Vendor Oversight	Upfront demonstration phases combined with readiness demonstration provides risk mitigation Coating design performance in the presence of process errors is evaluated and optimized		Working	10/2017: Opt-031 risk marked complete with completion of demonstration and coating readiness report delivered. Opt-031 risk relates to risk at time of coating. 7/2017: Vendor has demonstrated repeatability as part of demonstration runs. 12/16/15: Currently having vendors complete the demonstration phase		6/1/2018	6/1/2018	3	3	3	2	9.5	Minor	$200	$200	$1,500	Expected value is based on additional testing and analysis required to verify and costs with delaying Ball/AOS. Vendor submitted risk mitigation activity ($62K) to demonstrate coating tooling with full aperture optic with samples.	1.5	3.0	3.0	This assumes no rework, just time to evaluate and additional testing.	5%	25%	$10	$50	$180	62.50	0.15	0.75	0.75
I&T	3.08.01	IT-001	Science Raft Schedule	IF Science Raft tower delivery is delayed, THEN the I&T schedule and camera delivery will be delayed	Bond	I&T	1-Jul-16	3	3	4	1	9.5	Minor	Study	Flexible I&T Sequence	1) Develop I&T sequences with sufficient flexibility to rearrange ordering. Cryostat integration may be performed in two parts, first with all available science rafts, followed by camera integration, then continuing with remaining Science Rafts (DONE)		Hold	7/2016: Engineering test units were delayed. SR1 has slight delay but sufficient RTMs to start cryostat integration appears to be on track. 6/2015: Moved status to holding. Will hold until raft delivery starts. 6/2015: Adjusted probability to reflect SR status. 8/2013: added commissioning camera, which further mitigates impact of delays 9/2011: Developed detailed sequence to understand impact	ITC00425		4/1/2017	3	3	4	1	9.5	Minor	$200	$300	$500	Standing army cost of delays	3.0	3.0	6.0		5%	25%	$15	$75	$123	47.50	0.15	0.75	1.50
I&T	3.08.03	IT-031	RTM performance degradation	IF RTM performance degrades over time (flex cable failure, RTD failure, Sensor Glow) THEN RTM may have to be de-integrated and refurbished	Bond	I&T	6-Nov-17	3	3	3	2	9.5	Minor	Study	Early diagnostics	1) perform full EO test and metrology test at IR2 as part of the acceptance testing. (PLANNED) 2) perform an intermediary integrated test with 9 rafts to ensure performances still hold (PLANNED) Mitigations cover mainly the schedule part of the risk		Working	11/2017 initial entry	CD-4		11/1/2018	3	3	3	2	9.5	Minor	$0	$348	$1,218	Cost for repairing or upgrading RTMs (8K shipping plus $50K per rafts). Nominal would be a half the ITL RTMs (6 RTM)	1.5	2.0	3.0		5%	25%	$17	$87	$184	65.25	0.10	0.50	0.75
I&T	3.08.03	IT-037	Complete Cryostat Testing	IF extensive and complete cryostat final testing is not performed on the multichannel system prior to delivery to I&T THEN I&T will require additional time and resources to deal with any problems associated with non-conformance of the cryostat "full system" cooling requirements.	Bond	I&T	8-Jan-18	3	3	4	1	9.5	Minor	Study				Accepted	1/2018 - initial entry.	Final Cryostat testing with all rafts installed		2/1/2019	3	3	4	1	9.5	Minor	$200	$750	$1,500	Cost include $500k for salaries as well as additional $250k for misc equipment and hardware. (2 Eng + 2 Tech salaries at 4.5 mo ~$500k)	3.0	4.5	6.0	Time may be significant due to additional pumpdown and cold cycling required to address issues. -1.5 mo mod/tune refrigerant ratio. -1.5 mo remove/modify capillary. -1.5 mo reassemble and final test.	5%	25%	$38	$188	$311	117.50	0.23	1.13	1.50
I&T	3.08.01	IT-020	I&T Manpower	IF unplanned delays in integration and/or testing occur THEN second shifts will be required.	Reil	I&T	21-Jun-16	4	2	3	1	9.3	Minor	Study	Flexible Scheduling	1) review staff restriction on possibility for second shifts 2) review labor pool regulation for overtime		Working	Will need to coordinate with SLAC labor pool, lab management, etc	CD-4		9/1/2018	2	2	3	1	4.7	Insignificant	$30	$200	$500	Cost of overtime/Standing army cost if second shifts cannot be put in polace	1.5	3.0	12.0		1%	5%	$2	$10	$41	6.65	0.03	0.15	0.60
I&T	3.08.02	IT-027	Over-burdened SLAC TS8 due to TS8 downtime or inability to keep up with rate of science raft deliveries	If the TS8 system at SLAC cannot keep up with raft deliveries due to downtime or other problem then the camera will be delayed	Reil	Fab	14/5/2018	4	2	3	1	9.3	Minor	Study	Obtain spares for the SLAC TS8 system and rely on the BNL TS8 system for Raft testing	1) Fabricate a dedidcated I&T TS7 dewar to decouple from Corner Raft (COMPLETE) 2) Maintain Corner Raft TS7 Dewar after corner raft effort is over (PLANNED) 3) Purcahse spare parts for the TS7 Dewars (IN PROGRESS) 4) Procure parts neccessary for an additional TS7 (PLAN ON HOLD) 5) If RTM testing cannot keep up with raft delivery, plan to rely on BNL testing for selected rafts (i.e. eliminate some verification activities at SLAC)		Working	4/18 - Budget prepared for additional TS7 fabrication. Discussions with CR for use of CR TS7 when completed. 6/17 - Spare equipment has been purchased including pumps, valves and coolers. More equipment will be purchased as experience is gained in terms of identifying hardware that has a high failure rate 4/17 - Initial entry.	RTM22	12/15/2018	7/15/2017	2	2	3	1	4.7	Insignificant	$16	$32	$48	11/2017 If mitigation strategy #2 is implemented, there is a possibility (although low) that 1-3 Rafts may need to be returned to BNL for repair or that a RAFT installed into the camera cryostat may need to be removed. Cost per shipping is $8K per RTM	1.0	2.0	3.0	11/2017 If 1-3 Science Rafts end up being returned to BNL for repair, schedule delays of 2-3 months could be experienced (1 month per RTM returned).									
Opt	3.05.03	Opt-045	L1-L2 Lens damaged during fabrication/Ass embly	IF the L1 or L2 Lens is damaged during fabrication/assembly, THEN schedule, cost and/or performance will be impacted.	Wolfe	Fab	1-Mar-17	4	2	3	1	9.3	Minor	ETU	vendor oversight	Work closely with vendor, hold appropriate manufacturing readiness reviews, hold points and witness points in contract Prime contractor and vendor completes FMEA on processes, procedure reviews, and dry runs.		Working	3/2017: Minor L1 incident occurred that does not impact performance. Additional mitigations added per L1 incident report 150-00031. 10/2016: Added risk due to events at vendor		12/1/2018	10/1/2016	3	2	3	1	7.0	Minor	$30	$150	$200	Nov 2016 EAC realized part of this post-mitigation cost. Expected is the additional costs to provide more frequent on-site support to the vendor.	1.5	3.0	3.0	Potential impact above the current 7 months float	5%	25%	$8	$38	$54	20.75	0.15	0.75	0.75
I&T	3.08.03	IT-032	Refrigeration system maintenance during I&T	IF the refrigeration maintenance requires more time than planned due to contamination issues or performance issues, then I&T testing will be delayed	Bond	I&T	6-Nov-17	4	2	3	1	9.3	Minor	Study	Refrigeration system late technical issues	1) Efforts are being made to retain the expertise already developed in this area by the Refrigeration Subsystem Team.		Hold	11/2017 initial entry	CD-4		8/1/2018	4	2	3	1	9.3	Minor	$30	$150	$200	Cost for this issue are likely limited to the standing army costs associated with the increase in schedule.	1.5	2.0	3.0		25%	67%	$38	$101	$85	63.63	0.50	1.34	2.01
SE	3.02.01	SE-036	Camera body interface tolerances	IF camera back flange and housing do not comply with interface tolerances, THEN camera elements will not be aligned within tolerance, without modifying mounting methods	Nordby	I&T	11-May-18	4	2	3	1	9.3	Minor	Anal	Model as-built distortions and track fab tolerances	1. Do FEA simulation of assembly based on part distortions, and generate predictions of interface feature positions (STARTED); 2. Develop impact and recovery plans with affected subsystems; 3. Modify camera body assembly parts as needed to prepare for subsystem integration		Working	5/2018: Initiated risk; working on structural FEA model			8/1/2018	2	2	1	1	3.3	Insignificant	$30	$60	$200		0.0	0.5	0.5		1%	5%	$1	$3	$14	2.35	0.01	0.03	0.03
Cmr Rft	3.04.02.04	Crft-020	ITL Flex Cable mechanical integration	IF the LSST designed ITL flex cable is too stiff or cannot be secured adequately to the sensor THEN the corner raft cannot be assembled	Herrmann	Design	16-Mar-16	4	2	2	2	9.3	Minor	Study	Measure stiffness and prorotype securing cable	1) Measure flex cable stiuffness and review that preload on the yoke and arm is adequate (DONE) 2) Prototype and test methods for securing the flex cable to the sensor using mockup aluminum sensors and WFS mechanical devices is available (mitigation still pending) 3) conduct perormance evaluation and opticmization (PLANNED)		Working	3/2016: creation per the 03/16/2016 risk review board. Flex cable stiffness has been measured. Six Flexible Circuits will attach to the CRSA. In the installed position the geometry of the flexible circuits create a pre-load in the opposite direction as the Yoke and Arm hold-downs. The Flexible circuits decrease the pre-load on the kinematic mount by approximately .82N and is negligible. 4/2016: flex cable securing to the sensor is still a remaining risk. 03/2017: flex cables have had issues with the science raft team and risk carries over to the WFS flex cable. New mitigation is to add stycast to strenthens the cable. Risk increased until this is understood. 06/2017: flex cable design was completed. Fabrication and testsing is still needed. 09/2017: flex cable expected to go through fabrication in September. 03/2018 First CRTM assembly indicate flex is strongly bend (twisted) but seem to work, performance tests will follow		7/1/2017	11/1/2017	2	2	2	2	4.7	Insignificant	$30	$100	$200	Cost of making new cables	0.5	0.5	1.5		1%	5%	$1	$5	$19	3.15	0.01	0.03	0.08

LSST Camera Risk Registry

SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost
			Risk Identification	Risk Identification			Current Assessment		Impact of Risk			Exposure Level		Mitigation Plan			
Cryo	3.06.04.06	Cryo-057	Refrigeration System and Telescope interface	IF the telescope/observatory scope contract work is finalized before input from the refrigeration system, THEN the refrigeration system will need to develop alternative design and procure the material and parts for the change.	Callen			4	2	2	2	9.3	Minor			1. Meet regularly with TMA team 2. Keep ICDs updates current 3. Weight and review design options	
CB&M	3.06.01.02	CBM-048	Purge cabinet functionality	IF the purge cabinets do not provide cooling, filtering, and air flow rate as designed, THEN camera components and skin temperature will not be controlled to meet requirements	Nordby	Fab	14-Feb-17	4	2	2	2	9.3	Minor	Proto	Test purge cabinets with mocked-up thermal loads	1. Build purge cabinets early to provide time for early testing before integration. (NOT IMPLEMENTED BECAUSE OF U.T. DESIGN IMMATURITY) 2. Fabricate and assembly heat/flow simulators for purge cabinet testing. (Not started, but costed) 3. Test purge cabinets over a broad range of temperatures and heat load conditions to demonstrate that they function as needed (NOT IMPLEMENTED)	
SE	3.02.01	SE-035	As-built mass over allocation	IF enough camera subsystems exceed their mass allocations, THEN mass and CG reserves will not be adequate and the camera will exceed its mass/CG budget	Nordby	I&T	11-May-18	4	2	1	3	9.3	Minor	Anal	Track design and as-built mass changes with subsystems	1. Update LCA-119 Mass Report with mass of as-builts and updated designs (COMPLETE); 2. Work with Aux Elec to track cable and component mass 3. Get masses of advanced prototypes for Shutter, Exch System, UT, Refrig Heat-X, ...	
Crnr Rft	3.04.02.03	Crft-021	ITL Sensor stud length	IF the Guide sensor selected are ITL sensors, THEN the studs have to be removed and retrofitted, which could cause damage to the CCD or cause delays	Herrmann	Fab	5-Aug-16	4	2	2	2	9.3	Minor	Study	Develop procedures for retrofit	Two mitigations are available: - develop procedures for retrofit by the cornerr aft team (done and received from ITL) - work with vendor to have retrofit done at vendor (primed at vendor)	
CCD	3.03.02.02	CCD-006	ITL Flex Cable reliability	IF the ITL Flex Cable fails due to an open in the Flex Cable cirquit, THEN the RTM will experience a loss of connectivity with the imaging and/or RTM channels.	Wahl	Fab	20-Mar-17	3	2	3	3	9.0	Minor	Anal	Redesign Flex Cable	Redesign the Flex Cable to have a more robust transition at the rigid-flex transition on the REB side of the cable. Possible solutions are 1) pot the transition using a resin based epoxy like sStycast (This was tested successfully on ETU2 and RTM1) (DONE) 2) use a different type of connector that offers more rigidity at the solder connections (This was baselined) (DONE) 3) review control of sweeping bend radius of the flex cable during raft assebly (IN PROGRESS)	
Opt	3.05.02	Opt-020	Filter coating metrology	IF the filter coating vendors do not have the metrology needed to conduct verification needed (in particular in out-of band) THEN we may not know how the filter performs until in operation	Wolfe	Procure	19-Mar-18	3	2	3	3	9.0	Minor	Proto	Witness samples	Mitigation 1: Vendors will be asked during Ph3 (see Opt-001) to generate witness samples and verify this. We will then be able to assess the capabilities of the vendors. After delivery of the witness samples, there is significant schedule margin for a second witness sample phase if necessary. Mitigation 2: we can contract third party vendors or institutions (IN2P3 has agreed to help with witness sample verification) to measure the filters at time of delivery for independent verification	
Sci Rft	3.04.01.03	Srft-007	In-Camera Electronics Failure Rate	IF in-Camera electronic failure rate exceeds predetermined allowance THEN throughput will be degraded	Van Berg	I&T	5-Jun-15	3	2	2	4	9.0	Minor	Study	System design	- Conservative electronics design, redundant connector pins - Readily available spares, ease of replacement	
EXCH	3.06.03	EXCH-013	Filter hand-off	IF the Auto Changer and Carousel cannot reliably hand off filters, THEN we would be forced into re-design that would very likely impact operational capability of the system	Karst	Fab	16-Jun-17	3	2	2	4	9.0	Minor	Proto	Exchange system prototype	Construct a full Changer + Carousel prototype to demonstrate fail-safe operation of the mechanical system and low-level controls; Run a life-test prototype to characterize failure scenarios and contamination	

SS ID	Status	Status Description	Milestone	Date	Date Will Occur
			Target Retirement		
Cryo-057	Working	6/2017: This risk has been realized during regular meetings with TMA team. TMA has contract with vendors that are costly to modify. The team is working to update changes on the ICD. Some modification will be needed after the current contract work is complete.			6/1/2017
CBM-048	Hold	2/2017: purge cabinet design is being tweaked by UT; lack of closure on UT design is starting to be a problem for purge system; 11/2016: additional scope for environmental testing was not implemented, and a decision made to carry the risk through assembly and limited testing 9/2016: Identified this as a new risk; developed rough plan for prototyping	Camera Body Delivery	1/1/2018	6/1/2018
SE-035	Working	5/2018: Updated LCA-119 Mass Report to include actuals and allow for tracking of as-built mass 1/2018: Updated Mass Report to include as-built mass of Sci RTMs	Camera Body IRR	3/1/2019	5/5/2020
Crft-021	Working	8/2016: risk creation. Procedures for retrofit by LSST team has already been generated. ITL is providing feedback on procedures, expected in the next month or so. Retrofit at vendor will be addressed at time of guide sensor selection 10/2016: current approach is to use e2v M12 sensors, which do not have this issue. Procedures to replace the studs have been received from ITL. 03/2017: ITL sensors or mixed sensors are possible options (again) 02/2017: Current approach is still to use e2v devices. 05/2017: This is now baselined. risk reduced 04/2018: CR will probably use ITL sensors, tryouts with CR ITL studs seem OK		8/1/2018	7/15/2018
CCD-006	Working	4/16/18: The continual appearance of dead channels on ITL sensors suggests that we may not be out of the woods regarding flex cable reliability 12/8/17: A decision to not fabricate more rerouted or rerouted/shielded cables was made. Freytag instructed to load remaining 10 sets of production cables plus the 1 se each of rerouted & rerouted/shielded now at SLAC. These and the 5 sets (3 normal, 1 rerouted, 1 rerouted/shielded) now at BNL will be used for the remaining ITL rafts. 11/27/17: 4 RTMs of potted production cables are at BNL. One set each of rerouted and one set of rerouted/shielded cables are also at BNL. The 3 types are being evaluated. 7/13/17: More unshielded flex cables are under contruction. Designs for shielded cables have been produced and a decision of which design to fabricate is scheduled for the week of July 17-21 3/20/17 Based on recent experiences building ETU2 & RTM1, it is clear we have a problem in terms of breakage at the rigid-flex transition on the REB side of the Flex Cable. G. Haller & S. Herrmann are now working on a solution to make the transition more robust. The design will be tested prior to use, which will include destructive and non-destructive testing. The new cables will be needed by the time we construct RTM7 or RTM8 at the very latest.	RTM8	7/1/2018	3/1/2018
Opt-020	Working	3/2018: Vendor is comissioning metrology system. 6/2015 Filter FDR presented mitigation plan 3/2015 Metrology plan to be presented at Filter FDR - RFP review for Ph3 occured 2/18/2014		3/1/2017	2/1/2018
Srft-007	Working	5/15/18 As of May 2018, 13 Rafts have been constructed and tested to date (including 2 ETUs) and the REB electronics have performed as expected. This Risk would be retired already but there is a chance we will modify the remaining inventory of REBs to address the bias offset found in ITL Sensors. Probability will remain marked as "Possible" until a decision is made with regard to the upgrade. 3/19/18 All 22 sets of production REBs have been fabricated and tested with expected yield levels achieved. REB performance post RTM construction is demonstrating very good results and there is no indication that failures during Raft operation is likely. 10/18/16 Extensive testing is being performed on REB4 boards at SLAC including burn-in and thermal cycling. Early results are positive and more testing will be performed in November '16 shortly after the REB5 boards become available. Prior to October '16 ROAR and bench tests will provide insight into failure rates and point out any weak components.	End of REB5 Production Test	1QFY18	1/15/2018
EXCH-013	Working	05/2018 : A first Assembly of the dummy camera has been done in April. The first test of the Carousel with the Auto Changer is foreseen in May. 02/2018 : The delivery of the Dummy Camera is delayed to mid of March. The combined test is postponed to April 2018. 11/2017 : The delivery of the Dummy Camera is estimated end of february 2018. The combined test is postponed to March 2018. 06/2017 : Because of the delay in the Dummy Camera body fabrication, the test is postponed to December 2017 01/2017 : The filter hand-off with the full scale prototypes is planned to be demonstrated on the end of September 2017 9/2016 : Combined test postponed to March 2017. 6/2016 : The assembly of the sub-systems is delayed by three months, the combined test is postponed to December 2016. 5/2015: The Full Scale Prototype will be tested in combined configuration with all the sub-systems in October 2016 4/2013: The Single Filter Test, part of the prototype, has already performed more than 200 cycles of filter Hand-off Improvement have been identified. 5/2011: Starting design of the Autochanger and Carousel prototypes. Starting design of the test bench. 4/2010: waiting on personnel to design test unit	EXCH Proto Test	June 18	6/1/2018

SS ID	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments
	Residual Risk: Post-Mitigation Assessment	Impact of Risk			Exposure Level		Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)			
Cryo-057	4	2	2	2	9.3	Minor	$30	$75	$200		0.5	1.0	1.5	
CBM-048	4	2	1	2	8.0	Minor	$30	$100	$200	Residul cost associated with personnel to continue testing and modifying the design to function as needed	0.0	0.5	0.5	
SE-035	3	1	1	2	4.5	Insignificant	$0	$30	$30		0.0	0.5	0.5	
Crft-021	4	1	1	1	4.7	Insignificant	$0	$0	$30		0.0	0.0	0.5	
CCD-006	2	1	1	2	3.0	Insignificant	$0	$0	$30	If the Flex Cable is robust, there is very little opportunity for breakage especially after it is installed and the RSA is constructed.	0.0	0.0	0.5	
Opt-020	1	2	5	3	3.7	Insignificant	$30	$100	$200	Vendor under contract is developing system. This cost covers risk of system needing modification and LSST helping with costs.	6.0	8.0	24.0	
Srft-007	1	2	2	4	3.0	Insignificant	$30	$100	$200		0.5	1.0	1.5	
EXCH-013	1	2	1	1	1.7	Insignificant	$30	$30	$200		0.0	0.0	0.5	

SS ID	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
	Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
Cryo-057	25%	67%	$19	$50	$57	40.63	0.25	0.67	1.01
CBM-048	25%	67%	$25	$67	$66	48.30	0.13	0.34	0.34
SE-035	5%	25%	$2	$8	$10	3.75	0.03	0.13	0.13
Crft-021	25%	67%	$0	$0	$5	2.30	0.00	0.00	0.34
CCD-006	1%	5%	$0	$0	$1	0.15	0.00	0.00	0.03
Opt-020	0%	1%	$0	$1	$8	0.53	0.00	0.08	0.24
Srft-007	0%	1%	$0	$1	$8	0.53	0.00	0.01	0.02
EXCH-013	0%	1%	$0	$0	$5	0.29	0.00	0.00	0.01

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment: Risk Identification						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
									Impact of Risk				Exposure Level										Impact of Risk				Exposure Level																		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Opt	3.05.02	Opt-009	Filter coating damage due to stress	Stress on the filter may damage the coating in the form of delamination or micro-cracks	Wolfe	Fab	16-Mar-16	2	4	4	3	8.7	Minor	Proto	Filter witness sample test	Stress-test witness samples to qualify them for the max expected stresses/distortions 3/2016: Filter coating contract have witness samples that will be tested. Stress/strain evaluation will also be completed.		Working	9/2011:Not considered a manufacturing issue with vendors 3/2016: Vendors have indicated the stress/strain level is not an issue based on prior experience. Development plan includes the mitigation task		3/1/2017	1/1/2018	1	4	4	4	4.7	Insignificant	$1,500	$5,000	$7,500	Same cost but less probability; Filter coating valued at $280K/filters (no estimate available for stripping coating). If all filters needed to be re-done, total cost is ~$5,000K Pat's note: doesn't have costs of fixing the design so it doesn't happen again	3.0	4.0	6.0		0%	1%	$0	$50	$349	24.17	0.00	0.04	0.06
EXCH	3.06.03	EXCH-041	Carousel Full Scale Prototype Fabrication	If the full scale prototype is not ready in time for the validation of the design, then the design updating and the purchase of the final unit component will be delayed. The final units will not be delivered in time for the integration into the camera.	karst	ETU	16-Jan-17	4	1	4	1	8.7	Minor	Study	Detailed Development Plan	Identify the long-lead items and all the other delivery times. Define in the schedule the ultimate dates for ordering the final components. Detail the purchase plan of the prototype components in order to be ready to perform test and to valid the design in time. Establish a delivery and Test DashBoard with at minimun a monthly update. Send warning to the project management.		Working	05/2018 : The Back Flange has not been delivered. It is expected in May 2018. 02/2018 : The pre-assembly has started in january 2018, the assembly will start with the Back flange in April 2018. 11/2017 : The pre-assembly support is expected end of November. The assembly will start in January 2018 09/2017 : The beginning of the Carousel assembly is planned in October 2017. 01/2017 : The purchase will go on until the beginning of the final carousel assembly which is planned in September 2017 11/2016 : The purchase of the long lead items has started. 06/2016: Despite the delayed in the prototype assembly, we are still in time for mitigation the risk for the long lead item and for strating the procurement in fall 2106 05/2016 : Delivery of the Backflange at LPNHE the 10th of May. 04/2016 : The Dummy Back Flange machining is finished, the surface treatment is made, the delivery will be done end of April 2016. 03/2016 : Waiting for the Dummy back Flange, The aluminium ring is under assembly on a temporary frame. 02/2016 : WARNING - DUMMY BACK FLANGE DELEVERY END OD MARCH - 1 MONTH FLOAT LEFT 02/2016 : The assembly and test plan has been presented at CTM in February 5th. If the assembly starts in March 2016, the schedule presents that we could be able to purchase the long-lead items in september 2016 with a 2 months float. 01/2016 : The Dashboard is monthly provided 11/2015 : Dashboard and BOM in progress.	EXCH Final Unit	June 18	3/1/2020	1	1	2	1	1.5	Insignificant	$0	$0	$30		0.5	0.5	1.5		0%	1%	$0	$0	$0	0.03	0.00	0.01	0.02
Sci Rft	3.04.01.03	Srft-054	Pixel intensity correlation/over shoot	IF the sensors exhibit correlation (or anticorrelation) between adjacent pixels, THEN we will suffer PSF degradation	Stubbs	Design	5-Jun-15	4	1	1	4	8.7	Minor	Study	Characterization	We are seeing an anti-correlation between adjacent pixel flux values, origin not yet fully understood. It is manifest from both the Reflex and SAO controllers. If we can characterize this then we can correct for it.		Working	5/15/18 The effect is noticed on ITL rafts at TS8, but not on all sensors. LPNHE has written a detection code and is conducting tests. There is some evidence that the effect is lot-dependent but further testing is required. 10/18/16 Addressed in off-project sensor studies and through interactions with DES and HSC teams. 4/8/2014: Add specification 3/14/2014 Moved unfunded risk to residual risk	CD-4	7/1/2018	9/1/2018	3	2	1	1	5.0	Insignificant	$30	$100	$200	Assumes DM correction recovers performance	0.0	0.0	0.5		5%	25%	$5	$25	$42	15.75	0.00	0.00	0.13
SE	3.02.02	SE-024	Base Facility operations	IF the interface req's and plans for the Base Facility are not agreed on and scoped, THEN it may not support camera network connectivity and personnel during high-use periods	Johnson	Design	11-May-18	3	3	2	2	8.5	Minor	Study	Work out ICD requirements	Send T&S and DM teams camera needs for base facility and network connectivity; Work with Ctio SE to work through ICD agreements, including initiating new ICD's to capture base facility and long-haul network needs		Working	5/2018: Working with T&S tiger team to ensure camera details have been included 1/2018: Technical details are largely worked out, but costs and finalizing who pays for what has not. 1/2017: Observatory Tiger Team holding weekly meetings. Camera needs identified. 8/26/2015: Discussed at LSST community workshop. Office space and computer racks to be documented in LSE-65. Networking requirements to be defined in LSE-78. 7/7/2015: LCR-384 will put the base facility data center document under change control. The required camera rack space for the base facility is explicitly in that document. 6/5/2015: Status unchanged 4/27/2015: Personnel and speace inputs from camera team discussed in the 4/9 TOWG. No additional inputs are needed. 2/2015: we do not have an ICD, but we have provided input. Herrman is starting an IT plan. 9/2014: sent e-mail to Jeff Barr asking how best to proceed to ensure that camera reqs are factored into base planning. 7/2014: discussed at networking workshop in May (https://confluence.lsstcorp.org/pages/viewpage.action?pageId=6226468); results addressed all risks but this has not yet been codified in the appropriate ICD's; physical space was not discussed and remains an open issue; 9/2013: Sent camera use cases and req's to T&S and DM for comment--no response yet		6/1/2018	8/1/2020	3	2	2	1	6.0	Minor	$30	$50	$200		0.5	1.0	1.5		5%	25%	$3	$13	$30	10.75	0.05	0.25	0.38
Opt	3.05.03	Opt-016	L1-L2 change requests	IF interface and requirements changes are required for L1-L2 THEN we would have cost and schedule delays incurred by negotiation time with the vendors (due to design and build contract)	Wolfe	Fab	27-Oct-15	3	3	3	1	8.5	Minor	Anal	Contract setup	Firm Fixed Price contract has been established; important to define all ICD requirements with vendor early in Phase I; spec changes after Phase I have a more likely chance of change order		Working	10/2015 MOD 6 change in August resulted in cost increase. 7/2015 Working towards final design in late Aug 2015 5/2015 75% complete review held. 2/15/2015 PDR complete 7/2014: Firm Fixed-Price contract is in place; some ICD specs may not be fully defined to vendor 10/2013: Firm fixed price RFP was selected 7/2013: LLNL procurement office started evaluation		12/1/2018	10/1/2016	2	2	3	3	6.0	Minor	$30	$100	$200	Nov 2016 EAC completed realized some of this risk. Remaining risks lowered due to unknowns that may come up.	1.5	1.5	3.0	Currently 120 days of float.	1%	5%	$1	$5	$19	3.15	0.02	0.08	0.15
I&T	3.08.04	IT-016	Shutter Schedule	IF the shutter is delayed THEN final integration and test of the camera will be delayed. Associated standing army costs will be incurred. Early availability of carousel and filter exchange system can help mitigate.	Reil	I&T	21-Jun-16	3	3	3	1	8.5	Minor	Study	Shutter I&T coordintion	1) review I&T integration sequence to maintain 60 days of free float to shutter delivery (IN PROGRESS)		Working	06/2016 - Risk identified - Coordination has been underway for a while	CD-4		8/1/2018	2	2	3	1	4.7	Insignificant	$30	$200	$400		1.5	3.0	6.0		1%	5%	$2	$10	$37	6.15	0.03	0.15	0.30
I&T	3.08.04	IT-017	Back Flange Schedule	IF the back flange is delayed THEN integration of the carousel and/or camera body will be delayed. Second shift can help mitigate.	Reil	I&T	21-Jun-16	3	3	3	1	8.5	Minor	Study	CBS I&T coordination	1) review I&T and Filter Excahnge assembly sequence to maintain as much free float as possible (DONE) 2) Have the backflange assembled at IN2P3 with the filter excahnge system (PLANNED)		Working	06/2016 - Risk identified - Coordination has been underway for a while	CD-4		10/1/2018	2	2	3	1	4.7	Insignificant	$30	$150	$200		1.5	2.0	3.0		1%	5%	$2	$8	$24	4.15	0.02	0.10	0.15
I&T	3.08.04	IT-018	Camera Body Schedule	If the camera body assembly is delayed then integration and test of carousel, auto-changer and shutter will all be delayed. Second shifts will be required to catch up on schedule.	Reil	I&T	21-Jun-16	3	3	3	1	8.5	Minor	Study	CBS I&T coordination	1) review I&T integration sequence to maintain 60 days of free float to camera body delivery (IN PROGRESS)		Working	06/2016 - Risk identified - Coordination has been underway for a while	CD-4		8/1/2018	2	2	3	1	4.7	Insignificant	$30	$150	$200		1.5	2.0	3.0		1%	5%	$2	$8	$24	4.15	0.02	0.10	0.15
I&T	3.08.04	IT-019	Optics Filter Schedule	IF the full complement of filters is not available at final camera verification THEN filter mass simulators will be used and final testing and throughput testing with filters will delay camera ready to ship milestone or delivery without final throughput verification will be required.	Reil	I&T	21-Jun-16	3	3	3	1	8.5	Minor	Study	Optics I&T Coordination	We may need to ship camera without full throughput measure with all filters. This would transfer scope to early operations as we would perform tests on summit before instyalling camera.		Working	06/2016 - Risk identified - Coordination has been underway for a while	CD-4		8/1/2019	2	2	3	1	4.7	Insignificant	$30	$150	$200		1.5	2.0	3.0		1%	5%	$2	$8	$24	4.15	0.02	0.10	0.15
I&T	3.08.03	IT-021	DAQ Schedule	IF full DAQ is not available when final RAFTs are integrated THEN final camera verification cannot occur until it becomes available.	Reil	I&T	21-Jun-16	3	3	3	1	8.5	Minor	Study	DAQ I&T Coordination	1) weekly with CCS and DAQ to priporitize needs (IN PROGRESS) 2) plan to use the DAQ V2 for the 2 ETU test required (PLANNED). This mitigates the DAQ V3 with new COB availability		Working	06/2016 - Risk identified - Coordination has been underway for a while	CD-4		9/1/2018	2	2	3	1	4.7	Insignificant	$30	$150	$200		1.5	2.0	3.0		1%	5%	$2	$8	$24	4.15	0.02	0.10	0.15
I&T	3.08.02	IT-022	CCS Schedule	IF CCS software is not fully tested prior to verification testing THEN significant delays in test program could occur. Additional support of CCS development during I&T may be required.	Reil	I&T	21-Jun-16	3	3	3	1	8.5	Minor	Study	CCS I&T Coordination	1) weekly with CCS and DAQ to priporitize needs (IN PROGRESS)		Working	06/2016 - Risk identified - Coordination has been underway for a while	CD-4		9/1/2018	2	2	3	1	4.7	Insignificant	$30	$150	$200		1.5	2.0	3.0		1%	5%	$2	$8	$24	4.15	0.02	0.10	0.15

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment: Risk Identification						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																	
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Cam	3.01	CAM-039	L1-L2 Delivery	If the L1-L2 delivery delayed beyond the scheduled float, THEN the camera integration and test will be late	Riot	Procure	15-Jul-15	3	3	3	1	8.5	Minor	Study	L1-L2 Delivery	Maintain schedule float for unplanned events. Increase oversight to ensure performance on-time - BCR-19		Working	5/2018: L2 is now coated. L1 is at the coating vendor. 12/2017: L2 shipping was delayed to allow finding a better shipping company 11/2017: L1 delayed due to small fracture. Still expected on time for BBAR coating. No change in assessment. 07/2017: L1-L2 assembly is back on track. No expected delays to baseline delivery. 02/2017: strut incident not resolved yet due to mnufacturing issue with the new strut. Delayed by a few more weeks. 01/2017: strut incident is causing 1 month delay on the structure but is not impacting final delivery of integration. 10/2016: L1 and L2 incident have been resolved and there is no impact on delievry schedule 9/2016: the incident on L1 has been resolved. an incident on L2 has been reported and been mitigated. No change in assessment required. 5/2016: An incident on L1 will reduce the schedule float. It is currently estmate to reduce the float by a few month up to 16 weeks. No change in assessment yet. 7/2015: Updated residual risk analysis 10/2014: Entry. Schedule float ~136 days	CD-4	1/1/2019	1/1/2019	3	3	3	1	8.5	Minor	$100	$200	$733	Standing army cost for optics team. 2 optics people at $400k/year for 0 - 3 months. Note, not on critical path, so schedule impact isn't large, but there is a standing army cost. If delay is > 6 months, potentiall 11 months based on other programs, this will impact delivery and full Optics team standing army costs apply in addition. 2 people at $400k/year and 10 - 20 people at 200K/year	1.5	2.0	3.0		5%	25%	$10	$50	$112	40.83	0.10	0.50	0.75
Opt	3.05.03	Opt-022	L1-L2 structure fabrication schedule	IF L1-L2 fabrication takes more time than baselined THEN the project may not have enough schedule contingency to complete the work	Wolfe	I&T	19-Mar-18	3	1	5	2	8.5	Minor	Study	start vendors as early as they can	The firm fix price contract will be executed by phase and the vendor will be started as early as they can support. There is a possibility of 3 months additional shceudle marhin to be gained. Also, the coating time can be reduced by careful coordination with the vendors		Working	3/2018: Vendor is finalizing structure hardware fabrication. Consistent with L2 lens coating availability. 5/2017 Vendor delayed in inspection/testing. No impact to overall L1-L2 assembly due to Lens fab and coating schedule. '5/2015: 75% review complete '3/2015: L1-L2 procurement has been placed and in the final design phase. Will work with vendor to better understand schedule fabrication scheudle risks		7/18/2015	1/1/2019	3	2	3	2	8.0	Minor	$30	$100	$200	cost for optics sub-system procurement support	1.5	3.0	3.0		5%	25%	$5	$25	$42	15.75	0.15	0.75	0.75
Cam	3.01	CAM-027	Indirect cost change M&S SLAC	IF indirect costs on materials increase within the labs THEN resulting -CV's could force de-scopes or draw on management reserves.	Riot	Mng	15-Jul-15	3	3	3	1	8.5	Minor	Study	Manage Contingency	1) Manage contingency on a regular basis to minimize impact of cost increase		Working	5/18: updated residual cost to match work to go 2/18: updated residual cost to macth work to go 9/14: changed from SLAC to labs. Need to look at the potential cost with the current estimates 4/9/14: Split risks by lab and shop rate. Met with the SLAC Director and Deputy Director. Project will receive a memo stating that they do not anticipate our indirect rates changing. 3/12/14: Applied and have received reduced SLAC overhead for the project. Moved optics procurements to LLNL from SLAC. This will result in an increase in the indirect cost. Negotiating with LLNL for a reduced rate. 9/2011: Obtained commitments and projections on indirect costs from all institutions. 9/2013: SLAC indirect rates have increased and resulted on a significant draw on contingency.	CD-4	6/1/2020	10/1/2017	3	2	3	1	7.0	Minor	$30	$110	$193	Assume roughly 5.5M (as of 4/2018) of materials to go at SLAC and increase of 2% (up to 3.5%)	1.5	3.0	3.0		5%	25%	$6	$28	$44	16.56	0.15	0.75	0.75
Opt	3.05.02	Opt-001	Filter coating	If the bandpass characteristics and coating uniformity necessary for science cannot be designed THEN the survey photometric precision and accuracy requirements will not be met.	Wolfe	ETU	19-Mar-18	2	3	5	3	8.3	Minor	ETU	Filter coating tests	Primary: - Ph1: Perform analysis to determine the effect of coating uniformity on the photometric accuracy. Generate filter curves using thin film coating design software to demonstrate the LSST pass-band shape and understand its impact on performance. Investigate vendor coating capabilities & research what has been done for other programs. Demonstrates feasibility and sensitivity analysis of the coating uniformity.(COMPLETED) - Ph2: Perform design study at 1-2 vendors to develop preliminary designs for all filters that are consistent with manufacturing capabilities. This will provide a full engineering design, & validate engineering feasibility in meeting requirements. - Ph3: Perform witness sample coating on a large curved surface for all 6 filters. Achieves a physical demonstration of filter coating for large optics and enables vendor to work on issues that would arise for a production run. Demonstration of a first article filter for a specific wavelength. Secondary: Develop and prototype more robust calibration algorithms that can account for spatial non-uniformity of photometry dependent on source SED		Working	5/2018: Good uniformity was demonstrated on the zand y band witnmess sample runs. This is not band dependent and gives confidence that this is under control at the vendor. 3/2018: Design methodology for all bands except "u-band" appears to be working. Currently working on y-band. 6/2017: Vendor has been refining the design as part of the development phase. All bands, except the u-band, appear to be manufacturable. Testing is planned through Dec 2017. 11/2016: Vendor completed design and working toward demonstrating on witness samples in Mar 2017 5/2016 Vendor under contract to do demonstration samples for all coatings. Expected completion in May 2017. 6/5/2015 RFP for the witness sample expected in August. - Passbands defined - Requirement refined - Design study conducted with 4 vendors (JDSU, SAGEM, Asahi Spectra, Materion) - RFP review for Ph3 occured 2/18/2014		2/1/2018	2/1/2018	1	3	5	2	3.8	Insignificant	$200	$600	$900	If there is a scalling issue that is demonstrated when we move to full sized filters it will found on the first article filter. The cost to redo the first article filter is about $150k. The cost to recoat is about $150. We can assume $300k of additional coating development may be required.	1.5	12.0	24.0	schedule could be up to 2 years to re-make. Re-coating estimated at 6 months. If there is a scaling issue, it is unlikely that there would be a significant cost and schedule impact. Either the spectral change will be minor and the part will be accepted with a small performance impact and little to no schedule impact or the part will require re-coating, with the associated significant schedule impact and a low/no performance impact.	0%	1%	$0	$6	$42	2.92	0.00	0.12	0.24
Opt	3.05.04	Opt-018	L3 flange leak	IF the L3 flange does not hold vacuum, then the cryostat cannot be closed and tested	Wolfe	ETU	15-May-18	2	3	3	5	8.3	Minor	Proto	L3 flat and leak testing	A L3 flat that can be used for closing the cryostat independently of L3 is planned. Leak test on the L3 flange is planned.		Working	5/2018: Test Window assembly passed leak test at TSESO 11/2016: Test window will be vacuum tested in May 2017 3/2015: LCA-52 has leak requirements, L3 SOW calls out leak test for flat and lens assembly 7/2013: Planned. Still need leak requirements.			4/1/2018	1	3	3	5	4.2	Insignificant	$200	$300	$1,500		1.5	3.0	3.0		0%	1%	$0	$3	$37	2.42	0.00	0.03	0.03
DAQ	3.08.02	DAQ-001	Generic DAQ R&D effort	Generic R & D DAQ effort fails to deliver necessary infrastructure either in a timely fashion or not at all; this constitutes ~85% of total engineering effort required to produce the necessary DAQ system	Huffer	Design	19-Apr-13	5	2	1	1	8.3	Minor	Proto	Escalate risk to PPA	1-Increase capacity of the COB 10G switch, share development costs with other projects 2- Obsolete mitigatin: Distribute risk to other projects and escalate risk to PPA directorate level; must demonstrate working prototype of GEN-II hardware by CD-2 Review		Working	5/15/2018: Production prototype COB has been fabricated and is under testing. 12/2017: Schedule and division of labor between LSST and TID has been defined. Work has started. 11/2017 Funding is in place as of 1 Nov. Scheduling discussion with Gunther targeted for last week in November. 10/2017 BCR in place, discussions with Gunther to schedule effort will occur in October. 9/2017 LCN updated based on discussion at the camera project level. Awaiting disposition 7/2017 LCN in discussion at camera project 6/2017 LCN submitted, meeting with Gunther held to describe how the costs will be distributed. Next step is to present results of discusions with Vincent. 1/2017 Now covered in approved EAC but not yet in a BCR, negotiations with PPA on how much of the cost is shared. 11/2016 Risk reopened because the COB does not provide the expected 80GBPS (onluy provides 20GBPS) 2/17/2015 Production run accomplished, no longer any danger in this deliverable 11/2013: May be able to retire by January (will demonstrate production run for the detector R&D) 4/2013: No change 9/2011: 3/4 of functionality is demonstrated. 4/2011:Development work in progress and risk is being	CD-2 Review		3/1/2017	5	2	1	1	8.3	Minor	$30	$100	$200	Assumes no sharing of costs and funding is found by Jan 2017	0.0	0.0	0.5		67%	100%	$67	$100	$59	87.68	0.00	0.00	0.50
Opt	3.05	Opt-010	Lens BBAR coating damage due to stress	Stress on the lenses due to pressure may damage the BBAR coating in the form of delamination or micro-cracks	Wolfe	Fab	16-Mar-16	2	3	4	4	8.3	Minor	Proto	Lens witness sample test	Stress-test witness samples to qualify them for the max expected stresses/distortions		Working	11/2016: Stress testing of vendor samples complete. Large margins and no issues identifed. See Document-21896 in Docushare. 3/2016: Stress testing of witness samples provided by vendor is being completed at LLNL. Expect inital results in late March 2016. 6/5/2015: BBAR coating witness samples tested by vendor in late 2015. 9/2013: BBAR coating study RFP was sent out to vendors on 8/22/2013 9/2012: BBAR coating study and witness sample RFP is ready. Witness sample size and thickness selected to address cracks and delamination.		6/1/2017	10/1/2017	1	4	4	4	4.7	Insignificant	$1,500	$2,750	$3,500	Lens coating valued at $170K (no estimate available for stripping the coating) If new optics needed, cost is $2,570/optics. L3 most likely so one optics probably should be used for cost. Cost same with and without mitigation	3.0	6.0	6.0		0%	1%	$0	$28	$190	13.33	0.00	0.06	0.06

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Current Assessment: Impact of Risk				Current Assessment: Exposure Level	Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Probability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Probability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Cam	3.01	CAM-047	Personnel burning out	If personnel burns out due to sustained high pressure environment then they will need to take some time off and cause further delay	Riot	Mng	12-May-17	3	2	3	2	8.0	Minor		Manage workload	1) Manage schedule contingency with broader project 2) Review vacation plan to ensure people have enough time off 3) Update organization to prevent dual hatted positions (done as part of BCR-64)		Working	2/2018: requirement manager hired 11/2017: camera body and shutter CAM brought on board 10/2017: all dual hatted positions removed. Pending finding a CAM for camera body and shutter. Implemented in BCR-64. 07/2017: risk is still high and maintained 06/2017: additional people demsontrated evidence of stress. Risk increased. 05/2017: risk created due to evidence of team members being over-stressed	CD-4	6/1/2020	5/1/2017	3	2	3	2	8.0	Minor	$30	$50	$200	Cost of training replacement personel. Project is ramping down and LSST personnel would be available to cover burned out personel	1.5	2.0	3.0		5%	25%	$3	$13	$30	10.75	0.10	0.50	0.75
Cam	3.01	CAM-036	Lack of L1/L2 spares	If L1, L2 and/or the L1/L2 structure are damaged during construction or integration THEN the project would fail to meet KPP's and CD-4 milestone	Riot	Mng	15-Jul-15	2	4	5	1	8.0	Minor	Study	Process Controls	1) Plan all processes involving optical elements to minimize damage. 2)Carry spare material (L1 Boule). DONE and used as mitigation.. 3) Add training at AOS (DONE by BATC) 4) Add Ball oversight support (DONE with additon of BATC personnel at AOS) 5) COnduct shipping and handling dry runs at the various vendors (DONE)		Working	5/2018: both L1 and L2 shipped successfully to REOSC 12/2017: dry run showed that a better shipping company should be investigated 11/2017: additonal L1 fracture requires repair. L2 scratches accepted. 04/2017: L1 incident mitigated. Additonal preventing mitigations have been put in place 03/2017: a new incident occurred on L1 but was mjitigated without any performance impact. 01/2017: both incidents on L1 and L2 have been resolved. Risk remians the same dueing testing and integration. 9/2016: L1 blank replacement was completed in a timely manner. L2 damage partially realized the risk and has been mitigated via repair. no assessment change needed. 5/2016: L1 blank was damaged during shaping. Risk partially realized. L1 damage is being mitigated by replacing the blank with minimal schedule and cost impact. No performance impact. Raised risk probability to 2 given the pressure on getting L1 re-made and past experience. 9/12/2014: Keep a boule at the vendor for 6 months that can be used for either L1 or L2. Added $50K	CD-4	6/1/2020	6/1/2018	2	4	5	1	8.0	Minor	$2,000	$2,800	$7,300	L1/L2 blank is $800K each, processing of lens is $2M each. Total cost worst case to redo is $7.3M. Nominal is on lens to redo for $2.8M	6.0	11.0	12.0		1%	5%	$28	$140	$611	102.50	0.11	0.55	0.60
EXCH	3.06.03	EXCH-036	Broken mechanisms during transportation and Handling	If a major part or mechanism are broken or lost during the transportation or the handling, THEN it cannot be replaced quickly and the intergration will be shifted	Karst	I&T	16-Jun-17	3	2	4	1	8.0	Minor	Study	Transportation tools	Check the insurance for the device cost. Share the transport in several shipments.		Not Started	06/2017 : The final system shipment is planned on December 2018 01/2017 : The final system shipment is planned on October 2018. The prototype shipment in 2017 at Paris will allow a first mitigation level. 9/2016 : Next final unit shipment planned in December 2017 5/2015: The next shipment of the final units is planned for August 2017 09/2013 : Initial definition	EXCH Shipment	1/15/2019	3/1/2020	1	1	3	1	1.8	Insignificant	$0	$0	$30		1.5	2.0	3.0		0%	1%	$0	$0	$0	0.03	0.00	0.02	0.03
CB&M	3.06.02.02	CBM-043	Shutter functional reliability	IF Shutter components do not reliably function over their broad temperature and environmental conditions, THEN Shutter faults may result in unscheduled downs	Nordby	I&T	17-Oct-17	3	2	2	3	8.0	Minor	ETU	Shutter drive system test unit	1. Test stock components and lubricants to select long-life and low-shedding items; 2. Test components and system mechanics over full operating conditions in drive system test unit; 3. Test entire mechanism with Shutter prototype		Working	5/2017: Plan to test shutter proto and shutter in meat locker to demonstrate perf over temp range 8/2016: Prototype build is underway 11/2015: Spec'ing proto components for full survival temp range 5/2015: Drive system test unit underway 5/2014: developed concept for drive system test unit	12/1/2017	12/1/2017	10/1/2018	2	1	1	2	3.0	Insignificant	$0	$10	$30		0.0	0.5	0.5		1%	5%	$0	$1	$2	0.35	0.01	0.03	0.03
CCS	3.07.01.02.10	CCS-018	Sites adhering to data format standards	IF data formats and directory stuctures are not precisely defined and enforced, THEN conflicting data formats and directory structures make data curation and application of test algorithms difficult or impossible across testing sites.	Johnson	Design	22-May-15	3	2	2	3	8.0	Minor	Anal	Standardize data formats	Define and document standard data formats and directory structures completely and have the Camera project mandate that these standards be adhered to for all sensor testing.		Working	Data format standards for early test stands have been determined and documented. Standards for subsequent test stands have been developed and documented. 5/15/2018 So far adherence to established standards has been good, and we continue to monitor this risk.	I&T		10/1/2016	2	1	1	1	2.3	Insignificant	$0	$0	$30		0.0	0.0	0.5		1%	5%	$0	$0	$1	0.15	0.00	0.00	0.03
Opt	3.05.04	Opt-012	L1-L2 composite structure	IF L1-L2 composite structure has structural aging issues THEN image quality could be impacted half way through the survey (lifetime issue)	Wolfe	I&T	5-Jun-15	3	2	2	3	8.0	Minor	Anal	Analyze and survey composite design	Composite design will be assessed using standard tools to assess for lifetime issues. Structure will be tested after fabrication to ensure there are no defects.		Working	1/2015: Preliminary design indicates no issues related to aging of composite material 2/2013: Delta CoDR design provided a few ideas on survey methods for fabrication. Analysis of design expected to be done by vendor.	FDR		7/1/2019	1	2	2	3	2.7	Insignificant	$30	$150	$200		0.5	1.0	1.5		0%	1%	$0	$2	$10	0.69	0.00	0.01	0.02
Opt	3.05.04	Opt-033	L3 pressure null test	IF the L3 lens wavefront test does not properly account for "test" versus "use" conditions, THEN it may degrade the camera image quality.	Wolfe	Fab	6-Jul-15	3	2	2	3	8.0	Minor	Anal	Design and Testing	Design lens test to allow null testing without pressure differental across lens. Complete measurement of lens surface sag under pressure to verify modeling.		Working	7/2015: Working with vendor on final design and testing			10/1/2018	1	2	2	3	2.7	Insignificant	$30	$30	$200		0.5	1.5	1.5		0%	1%	$0	$0	$5	0.29	0.00	0.02	0.02
Cryo	3.06.04.06	Cryo-026	Refrigeration: Contamination Recovery	IF adequate and efficient processes for removing contamination from the refrigeration system cannot be developed and employed THEN plugged or frozen refrigeration units will require more time to repair then allotted for by camera subsystem requirements..	Callen	ETU	20-Sep-16	3	2	2	3	8.0	Minor	ETU	contamination isolation and removal	1) include filters and desiccators at critical locations to ensure contamination transport is restricted and isolated for removal. 2) Develop and test designs of critical components that allow less complicated replacement. 3) Develop alternative approaches to systems requirements, configuratins and operations that increase redundancy. 4) Procure, test and validate systems that allow in-situ decontamination.		Working	3/2018: We will install and process the refrigeration lines in Chile to gain more control of the progress to reduce contamination. 3/2017: Based on experience, the current procedure are sufficient. There is still risk because of the plumbing we receive. 9/2016: New procedures and equipment have resulted in miminal contamination. Also, MMR is developing an easy to use cleaning refrigerant. Early results show improved performance with this cleaning procedure. However, it will requires some thermally cycling of the evaporator (therefore camera in real life). We could minimize the delta T by using the heaters. 10/2015: consider retiring and tracking one contamination risk, once LCN is approved. 2-2016: contamination events intemitant due to component failures and processing development, filters may be issue for fuinctionality, risk remains high new "low contmaintion risk" hardware is developed and filters are evaluated in greater detail 9-2015: no new assessment, no contamination events since last reporting / update 5-2015: Updated Residual Risk 2-2015: no new risk update as we have not had a contamination event to test protocols and hardware and we have no had opportunity or desire to risk test systems with a "forced" contamination event. 10-2014: Continue to investigate and test methods of recovering system performance from "post contaminated state". Success is a direct function whether the flow is reduced or stopped. If stopped the system has had to be disassembled, which is an unacceptable condition. Development of methods of clearing a completely plugged	CD-4	5/1/2016	6/1/2018	3	1	2	3	6.5	Minor	$0	$30	$30	Assumes risks are not mitigated in ETU phase and continued effort is required during I&T and at the observatory	0.5	1.0	1.5		5%	25%	$2	$8	$10	3.75	0.05	0.25	0.38
Crnr Rft	3.04.02.03.01	Crft-016	Corner raft sensor alignment	IF the individual sensor nominal height is not what is expected THEN iterations may be necessary to adjust the height of all sensor on the corner raft baseplate	Herrmann	Fab	5-Jun-15	3	2	3	2	8.0	Minor	Anal	Update design and work with I&T on integration adjustment	The entire corner raft can be adjusted using different balls to place the guide sensor at the same height as the science raft. Within the corner raft, the design can be improved to prevent shimming (manufacturing cost will go up, captured in the residual risk) Mitigation planned at time of I&T and Corner Raft assembly.		Working	8/2014: risk approved for creation at the 08/20/2014 risk review board 5/2015: The wavefront sensor FDR was completed in May 2015 and work with vendor is ongoing to ensure package height is understood. 05/2016: a relaxation of the separation mid-point requirement is under way (See LCR-617) to help mitigate this issue. 10/2016: Znom needs to be resolved soon to ensure we close this out. 02/2017: znom was resolved. sensor height is still a concern during assembly.	CD-4	12/1/2017	11/1/2017	2	2	3	2	5.3	Minor	$30	$200	$200		1.5	2.0	3.0		1%	5%	$2	$10	$30	5.15	0.02	0.10	0.15
CB&M	3.06.02.02	CBM-045	Personnel for prototyping	IF we cannot add engin, design, and tech personnel for prototype work, THEN the work will be delayed, affecting schedule float and delaying burn-down of other risks	Nordby	Design	12-May-17	3	2	3	2	8.0	Minor	Study	Hire personnel	1. Hire new shutter engineer by May, 2015; (COMPLETE) 2. Bring on extra designer for proto work by May, 2015; (COMPLETE) 3. Work with I&T and cryo to identify additional tech to come onto camera to support proto work and beyond; (COMPLETE)		Accepted	2/2017: added S&E associate to manage and perform prototype work 11/2016: All mitigations implemented and shutter schedule re-arranged to buy more float to critical path, but this problem persists and will likely result in further delays 8/2016: Borrowing M.E. from I&T to push through prototype work 3/2016: New designer starts 3/14; req for M.E. on the street;techs are available but too early for dedicated 11/2015: Working to bring on a replacement designer to work through prototype design load 7/2015: M.E. hired, starting mid-July 5/2015: Interviews underway for new M.E. 3/2015: reviewing resume for M.E. hire	9/16/2016	9/16/2016	12/1/2018	3	2	3	2	8.0	Minor	$30	$150	$200		1.5	3.0	3.0	Additional 3 month delay of final shutter delivery is possible	5%	25%	$8	$38	$54	20.75	0.15	0.75	0.75
SE	3.02.01	SE-037	Incomplete verification of subsystem interfaces	IF subsystem interface requirements have not been finalized, THEN hardware will not be adequately verified to meet interface needs	Mendez	I&T	11-May-18	3	2	3	2	8.0	Minor	Study	Update ICDs prior to verifying and delivering units	1. Review and update ICDs prior to verifying subsystem hardware; 2. Incorporate ICD reqs into verification plans		Working	5/2018: Initiated risk; working with subsystems to flesh out details in ICDs prior to verification planning		7/1/2019	2/1/2020	2	1	1	1	2.3	Insignificant	$0	$30	$30		0.0	0.5	0.5		1%	5%	$0	$2	$4	0.75	0.01	0.03	0.03

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Opt	3.05.04	Opt-014	L3 fabrication	IF L3 fabrication is more expensive/longer schedule than baselined THEN the project may not have enough contingency to complete the work on time and budget	Wolfe	I&T	15-May-18	4	2	2	1	8.0	Minor	ETU	Procurement plan	Vendor will be involved for optics fabrication. Interfaces with cryostat body will be reviewed early. Procurement strategy is to engage design-build vendor with fixed-price contract for L3 optical flat + flange as test unit prior to constructing L3 lens flange; requiring vendor to implement rigorous environmental tests of integrated assy reduce post-delivery risk		Working	5/2018: Vendo has experienced a few more delays but altered work order to mimimize impact. Optic polisihing is complete. 5/2017: Updated risk. Vendor has delayed schedule and we are implmenting mitigating items. 10/2016: Updated risk. Added residual cost for testing scope chnage to help schedule. 6/2015: Contract awarded with favorable conditions 5/2015: Expected award is consistent with baseline cost and schedule. 7/2014: ROM pricing from multiple vendors for L3 optical flat + flange assy and L3 lens + flange assy 5/2013: ITT exelis and L3 have been engaged for fabrication schedule		6/1/2018	3/1/2019	3	2	1	1	5.0	Insignificant	$30	$200	$200	Fabrication support is required to help maintain delivery schedule to I&T. Estimate $200K.	0.0	0.5	0.5	Delay beyond current float of 60 days.	5%	25%	$10	$50	$67	25.75	0.03	0.13	0.13
CB&M	3.06.01.01	CBM-047	Camera body seal integrity	IF the shroud covers, porthole covers, or bay covers cannot provide reliable seals, THEN the camera volume may not be kept adequately clean	Nordby	Fab	14-Feb-17	4	2	2	1	8.0	Minor	Proto	Test prototype seal geometry	1. Prototype sheet metal covers, curved sealing surfaces, and captured fasteners for all 3 cover geometries. (BCR NOT IMPLEMENTED) 2. Test and select the gasket material type, durometer, and thickness that produces the most reliable seal (BCR NOT IMPLEMENTED)		Hold	11/2016: BCR for the cover seal prototyping was not implemented, and a decision made to carry the risk through manufacturing and assembly 9/2016: identified this as a new risk as the final design is completed	Camera Body Delivery	1/1/2018	2/1/2018	4	2	2	1	8.0	Minor	$30	$100	$200	Re-work all sealing surfaces; possibly re-fab some of the cover types for better sealing	0.5	1.0	1.5		25%	67%	$25	$67	$66	48.30	0.25	0.67	1.01
Cryo	3.06.04.06	Cryo-079	Heat Exchanger Multi-System Testing	IF the refrigeration system has issues with operating all circuits simultaneously, THEN unplanned downtime maybe required.				4	2	2	1	8.0	Minor			1) test with 2 circuits (DONE) 2) Coordinate with I&T to work on activities in parallel (PLANNED)		Working	3/2018: created				4	2	2	1	8.0	Minor	$30	$40	$200	1) change the filter dryer at the compressor (a couple of days), plus low cost filter <$20K 2) Add heaters to the capillary (needs to be done at I&T). Do it once (couple of man weeks) < 20K	0.5	1.0	1.5		25%	67%	$10	$27	$44	29.90	0.25	0.67	1.01
Cryo	3.06.04.06	Cryo-081	Cryostat Refrigeration Integration	IF the integration fixture for the cryo and cold evaporator tubes to the refrigeration lines are too constraint by the design, THEN the fixture design will be more complex to fabricate and the integration process may take longer than planned				4	2	2	1	8.0	Minor			1) Fabricate a mock-up feedthrough bellow assembly and validate the integration fixture and assembly sequence. 2) Hold a peer review to evaluate the mock-up		Working	5/2018: At the heat exchanger MRR peer review in April, it was apparent the cryostat and heat exchanger circuit integration will be challenging due to the space constraint in the design. A mock-up should reveal challenges for the integration process.				3	2	1	1	5.0	Insignificant	$30	$75	$200		0.0	0.5	0.5		5%	25%	$4	$19	$36	13.25	0.03	0.13	0.13
Opt	3.05.04	Opt-019	L1-L2 settling time and acceleration loads	IF the L1-L2 response is not fully understood THEN L1-L2 may not settle in time for proper image quality performances	Wolfe	Design	5-Jun-15	2	3	4	3	7.7	Minor	Study	Work with Telescope	Complete analysis to show the L1-L2 settling time meets requirements		Working	2/2015: Preliminary results presented at L1-L2 PDR. No issues identified. 7/2014; Contract with vendor includes settling time and modal requirements 2/2014: RFP for L1-L2 inlcuded settling requirements. Accelearion loads should be flowed down to understand this better. 7/2013: risks brought up at the L1-L2 procurement review	FDR		8/1/2019	1	3	4	3	3.8	Insignificant	$200	$500	$1,500		3.0	6.0	6.0		0%	1%	$0	$5	$46	3.08	0.00	0.06	0.06
I&T	3.08.02	IT-013	I&T Software	I&T has planned to (and has) relied heavilty on SLAC scientific software personel. (Contributed labor). IF this software support is not supported by SLAC THEN I&T will need to hire software expertise at additional cost.	Reil	I&T	21-Jun-16	3	3	2	1	7.5	Minor	Study	SLAC Software Coordination	1) ensure some CCS sustaining engineering is available in the I&T budget (DONE) 2) engage contributed labor supporting I&T early to maintain interest (In PROGRESS)		Working	06/2016 - Risk identified - Coordination has been underway for a while	CD-4		10/1/2017	2	3	2	1	5.0	Insignificant	$200	$200	$350	Contributed labor to I&T softare related is 1 FTE	0.5	1.0	1.5	delay to find software personnel	1%	5%	$2	$10	$39	6.75	0.01	0.05	0.08
ELX	3.08.03	ELX-001	System electronics design	Lack of a design for system electronics components in the Utility Trunk leaves large uncertainty in volume, mass, cooling, and access plans for UT	Haller	Design	7-May-18	3	3	2	1	7.5	Minor	Study	System elec design development	Install components and wire and test.		Working	5/7/18: components and wiring are being installed, when system is operational, it will be shown that no more items are needed 9/2011: Developed working conceptual design of system electronics, packaging and Utility Trunk. 5/26/15: Have complete system component and interconnectivity list. Need to include this into the UT mock-up when ready. 8/6/16: still work in progress	Auxiliary Electronics FDR	6/1/2018	9/1/2018	1	2	1	1	1.7	Insignificant	$30	$50	$200		0.0	0.0	0.5	Assumes need is found in time and the 50K is spent on engineering in time to eliminate schedule delay	0%	1%	$0	$1	$5	0.36	0.00	0.00	0.01
CCS	3.07.01.02	CCS-025	Observatory visualization software	If an observatory wide plan for development of visualization software with required functionality and availability timescale suiteable for use by the camera for I&T THEN the camera team may have to develop their own visualization system which may require more manpower than planned and/or provide less functionality than desired..	Johnson	Design	22-May-15	3	3	2	1	7.5	Minor	Study	Coordinate with Observatory	3/24/2014 A workshop is happening at SLAC in March 2015, bringing together developers from IPAC, U of I and SLAC, to coordinate future developments. Organize a series of meetings to collect visualization requirements from each observatory subsystem, identify common requirements, and propose to observatory management a program for developing common tools on the timescale required.		Working	We have developed a plan for joint development of a visualization system with the data management team and IPAC. A first status meeting was held at NCSA on 5/21/15 and considerabrle progress had been made since the first meeting on 3/24/15. 11/1/16 We have continued to have regular meetings with IPAC team, and have produced a first version of the camera visualization tool based on FireFly. 5/15/17 Initial version of visualization system is now deployed in IR2. 5/15/2018 We are maintaining the existing firefly based visualization sytem, and expect to make use of it during full camera operations beginning in FY 2019. We are trying to use observatory standards where possible, although the risk of bifurcation remains. The current risks level is appropriate	I&T		8/1/2017	2	3	1	1	4.3	Insignificant	$200	$300	$1,500		0.0	0.0	0.5	Assumes funding for additional manpower so the schedule is not impacted	1%	5%	$3	$15	$92	14.50	0.00	0.00	0.03
Cam	3.01	CAM-003	Key staff availability	IF key positions cannot be filled or key staff are lost, THEN project and technical progress will be delayed	Riot	Mng	15-Jul-15	3	3	2	1	7.5	Minor	Study	Draw from collaboration	1) Understand staffing needs early and recrut to ensure continuity. 2) Ensure appropriate staffing is available for activities near critical path. 3) Draw staff from institutions within the collaboration and/or utilize consultants to bridge a hole.		Working	2/2018: requirement manager hired. Walt Innes passed away 12/2017: requirement manager position still problematic to fill (2 offers were made and rejected by the two applicants). 11/2017: all position filled except for requriement manager. 10/2017: requirement manager positon search active with 3 candidates down-selected. Expected to make offers by end of October. Camera Body and Shutter manager position open 07/2017: I&T manager position was filled. Requirement manager position is expected to be vacant due to retirement. PM position is still pending. 01/2017: I&T manager position is still needed. Increased probability 10/2016: Sensor procurement manager has been identified and put in place (Tom Markiewicz) 9/2016: key position are missing as on 09/2016. Requisitions are in place and internal searches are ongoing. Positions missing are (I&T manager, Sensor procurement manager, permanent PM, interim deputy PM) 5/2016: Per the plan, the FTE profile showed a peak in Q1/Q2 of FY16, whihc has now passed. Probability of not filling key position is reduced as the team does not need to grow. 7/2015: new engineer for shutter has started, considering making an offer to a second engineer. 6/2015: Current resources are adequate to maintain schedule. Additional key hires still needed. Forecast schedule being updated to understand the longterm slip in schedule. 5/20/2014: Hirirng	CD-4	6/1/2020	6/1/2017	3	3	2	1	7.5	Minor	$30	$250	$500	Max exposure if full cost for one person over 2 years.	0.5	0.5	1.5		5%	25%	$13	$63	$102	38.25	0.03	0.13	0.38
EXCH	3.06.03	EXCH-048	Auto Changer THK Linear rails procurement	The lead time for the THK linear rails of the final Auto Changer is now 46 weeks, If there is not any other solution than buying new rails, then the Final Auto Changer delivery will be delayed.	Karst	Procure	13-Oct-17	4	1	3	1	7.3	Minor	Study	Using Prototype component	The Final linear rail design is the same than the prototype one. The Prototype can be used on the final unit waiting for the delivery of the new rails. Discussing with the supplier for decreasing the lead time.		Working	11/2017 : The THK rails have been ordered in November 2017, the delivery time is 36 weeks - Expected end of June- it could match with the Final Auto Changer Assembly. 10/2017 : Initial Status	EXCH Procuremen t	July-18	3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$30		0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
Cryo	3.06.04.06	Cryo-049	Cryo water chiller setpoint	IF the refrigeration system will not meet specifications using chilled glycol supplied by the observatory, THEN a different or modified chiller system will be needed	Callen			4	1	2	2	7.3	Minor			1) Run setpoint test 2) Add parallel circuit on the compressor 3) Add boost pump to increase flow		Working	2/2018: Need to check Chiller lines will be insulated. Update ICD. Impact Cryo compressors. Forward MMR's initial pressure drop report from 12/2017. 4/2017: This risk has been realized due to the pressure drop. 3/2017 Weekly meeting with observatory team to address specifications in LSE-64. Water chiller setpoint testing is in the plan.			4/28/2017	4	1	2	1	6.0	Minor	$0	$10	$30		0.5	0.5	1.5		25%	67%	$3	$7	$8	5.37	0.13	0.34	1.01
Opt	3.05	Opt-038	L3 (and L1, L2) lens damaged during coating period	IF lens is damaged during the coating period, THEN schedule and cost impacts will be incurred	Wolfe	Fab	15-May-18	2	3	5	1	7.0	Minor	ETU	Vendor Oversight	SOW specifies key process review/approval and witness/hold points Shipping container approval by LSST Vendors have proven experience handling large optics Insurance provided for L1, L2 and L3 during shipping Load tests for all fixturing/tooling Experienced personnel providing vendor oversight		Working	5/2018: L2 was coated successfuly. Coating vendor addded small marks on edge that are being removed. Small schedule impact. 2/2018: Insurance coverage for L1, L2 and L3 during shipping and coating vendor. Improved shipment oversight provided by freight-forwarder. 10/2017: Added L1 shipping ring to complete shipping of surrogate L1 to coating vendor for dry-run. 7/2017: Shipped surrogate L2 from fabrication to coating vendor to evaluate interfaces and mitigate risks. 12/16/15: Assuring procurement documents and vendors meet the mitigation descriptions.			8/1/2018	2	3	5	1	7.0	Minor	$200	$750	$1,500	Insurance provdied up to $2M to replace. Assume L1 new boule required, fabrication and oversight, so up to $1.5M required additional LSST/BATC resources.	6.0	16.0	24.0	Assumes time from ordering new boule to having lens coated.	1%	5%	$8	$38	$141	23.50	0.16	0.80	1.20

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment: Risk Identification						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Probability	Impact of Risk: Cost	Impact of Risk: Schd	Impact of Risk: Perf	Impact of Risk: Score	Exposure Level: Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Probability	Impact of Risk: Cost	Impact of Risk: Schd	Impact of Risk: Perf	Impact of Risk: Score	Exposure Level: Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Cam	3.01	CAM-042	Standing Army Costs additional year (delayed 2 years)	If the camera is late on elements (filters, rafts), THEN standing army costs will be needed to complete the project	Riot	Mng	15-Jul-15	2	3	5	1	7.0	Minor	Study	Standing Army	Manage contingency relative to float.		Working	9/2017: Project has 22 months of float 10/2014: Entry. Project has 24 months of float	CD-4	6/1/2020	10/1/2018	2	3	5	1	7.0	Minor	$600	$1,200	$2,400	Assume I&T standing army cost of worse case $200K/month (FY19 I&T monthly cost) and nominal of 100K per months (reduce this to minimal standing army)	12.0	24.0	24.0		1%	5%	$12	$60	$231	39.00	0.24	1.20	1.20
Opt	3.05.03	Opt-028	L3 (L1, L2) Coating Coordination	IF L3 (L1, L2) can not be coated within the 6 month schedule window. THEN L3 (L1, L2) coating maybe delayed and additional costs incurred.	Wolfe	Procure	15-May-18	3	2	3	1	7.0	Minor	Anal	Vendor Oversight	monitor schedules of L1, L2 and L3 production while maintaining close communication with coating vendor		Working	5/2018: L2 coating complete. L1 at coating vendor and is chedulel for coating in August. 3/2018: Vendor has reported delays in coating chamber availability. L1 delays have the highest risks. 5/2017 Vendor is completing phase 1 and we are preparing to award phase 2 (L1, L2 coating). Coating chamber utilization is very high through 2017. 6/2015 L3 contract awarded Will be part of coating vendor discussions		2/1/2018	3	2	3	1	7.0	Minor	$30	$100	$200		1.5	2.0	3.0		5%	25%	$5	$25	$42	15.75	0.10	0.50	0.75
Cam	3.01	CAM-029	Indirect cost change LLNL	IF indirect costs or shop rates increase within the collaboration, THEN resulting - CV's could force de-scopes or draw on management reserves.	Olivier	Mng	15-Jul-15	3	2	3	1	7.0	Minor	Study	Manage Contingency	Manage contingency on a regular basis to minimize impact of cost increase		Working	5/2018: change cost exposure to match remaining dollar amount 11/2017: updated with cost to go of $10M. Assume 3% change. 9/14: LLNL labor and materials to go is 26M. Assume 3% change. 4/9/14: Split risks by lab and shop rate. Need to validate with LLNL management	CD-4	6/1/2020	10/1/2018	3	2	3	1	7.0	Minor	$30	$195	$650	5/2018: LLNL labor and materials to go is 6.5M (as of 4/2018). Assume 3% change. (worst case is 10%) 3/2018: LLNL labor and materials to go is 7.7M (as of 3/2018). Assume 3% change. (worst case is 10%)	1.5	3.0	3.0		5%	25%	$10	$49	$101	36.50	0.15	0.75	0.75
Opt	3.05.02	Opt-017	Filter first article fabrication	IF filter first article fabrication is delayed THEN filter coating mitigation is impacted and confidence in coating may not be obtained in time	Wolfe	ETU	12-May-17	3	2	3	1	7.0	Minor	Proto	Review schedule and funding milestones	Interface with vendors and integrate funding/schedule with overall camera schedule and funding profile		Working	5/2017: Vendor has been delayed due to manufacturing issues, but still have ~80 days float. 7/2013: filter first article coating is delyaed passed CD-3 with coating evaluating in place before actually final filter coating		4/1/2017	7/1/2017	2	2	2	1	4.0	Insignificant	$30	$60	$200	Assumes impact to coating vendor costs to hold chamber and standing army costs.	0.5	0.5	1.5		1%	5%	$1	$3	$14	2.35	0.01	0.03	0.08
Cam	3.01	CAM-028	Labor rate change BNL	IF labor band rate increase within the collaboration, THEN resulting -CV's could force de-scopes or draw on management reserves.	Wahl	Mng	15-Jul-15	3	2	3	1	7.0	Minor	Study	Manage Contingency	1) Manage contingency on a regular basis to minimize impact of cost increase		Working	5/2018: update exposure to match work to go 11/2017: comprehensive EAC for FY18 completed with no changes 10/2016: Comprehensive EAC is expected to be complete by December 2016. Most current rates will be used to monitor contigency levels 9/2014: labor to go is 8M. Indirects on project are guaranteed. 4/9/14: Split risks by lab and shop rate. Need to validate with BNL management	CD-4	6/1/2020	10/1/2017	3	2	3	1	7.0	Minor	$30	$49	$163	5/2018: 1.35M labor to go. (as of 4/2018) and $280K material to go (as of 4/2018) Assume 3%. (worst case 10%) 3/2018: 1.6M labor to go. (as of 3/2018) and $450K material to go (as of 3/2018) Assume 3%. (worst case 10%)	1.5	3.0	3.0		5%	25%	$2	$12	$26	9.72	0.15	0.75	0.75
I&T	3.08.01	IT-002	Optics Schedule	IF Optics delivery schedule is delayed, THEN the I&T schedule and camera delivery will be delayed	Bond	I&T	14-Jul-16	3	2	3	1	7.0	Minor	Study	Flexible I&T Sequence	1) Develop I&T sequences with sufficient flexibility to rearrange ordering, including running some verif tests w/out L1-L2 and/or filters, using optical flat for L3, and delivering filters directly to the summit (DONE) 2) Update I&T sequence to maintain at ;least 60 days of free float (IN PROGRESS)		Hold	6/2016: L1 had damage, optics appears to hold schedule. L3 Some review delays but MRR in July 2016.6/2015: Moved status to holding. Will hold until Optics delivery established. 8/2013: added commissioning camera, which further mitigates impact of delays 6/2013: better definition of verif testing indicates we have some schedule flexibility to work around delays 9/2011: Developed detailed sequence to understand impact	ITC00475		7/1/2018	3	2	3	1	7.0	Minor	$30	$150	$200	Standing army cost	1.5	2.0	3.0	project delayed by one month thus total delay to camera reduced to (3-1=) 2 months.	5%	25%	$8	$38	$54	20.75	0.10	0.50	0.75
ELX	3.08.03	ELX-004	Cabling Plant	If there is not enough space for cables and plumbing to route to the various boxes and the Cryostat flange then redesign of some elements may be needed.	Haller	I&T	7-May-18	3	2	3	1	7.0	Minor	Proto	Prototype services routing	Install components and wire in quadrant boxes		Working	5/7/18: in progress 8/6/16: Still in progress 11/14/2013: New 3D model and feedthrough designs seems encouraging - total cable volume reduced some by JTAG to USB change 5/16/15: construction of a mock-up of the utitlity trunk has just started	Auxiliary Electronics FDR	6/1/2018	9/1/2018	3	2	2	1	6.0	Minor	$30	$75	$200		0.5	1.0	1.5		5%	25%	$4	$19	$36	13.25	0.05	0.25	0.38
I&T	3.08.03	IT-033	Utility trunk utilities during BOT activities	IF the Utility Trunk utilities are not available during BOT testing due to maintenance issues or capabilities shortfalls, then BOT testing will be delayed	Bond	I&T	6-Nov-17	3	2	3	1	7.0	Minor	Study	Utility Trunk Scheduling	1) Higher resolution analysis of the UT deliverables is under way to identify key elements that may cause delays, and their scheduling is being accelerated.		Working	11/2017 initial entry	CD-4		11/1/2018	3	2	3	1	7.0	Minor	$30	$150	$200	Cost for this issue are likely limited to the standing army costs associated with the increase in schedule.	1.5	2.0	3.0		5%	25%	$8	$38	$54	20.75	0.10	0.50	0.75
I&T	3.08.03	IT-035	Refrigeration Engineering Expertise	IF complications arise in the I&T refrigeration phase that are too complicated for the nominally designated I&T sustained Refrigeration Engineer, THEN additional "expert" resources may be required for resolution of those complications.	Bond	I&T	28-Nov-17	3	2	3	1	7.0	Minor	Study	Refrigeration Expert	1) Expert resources have been identified for mitigation of refrigeration related issues.		Hold	11/2017 initial entry	CD-4		5/1/2018	3	2	3	1	7.0	Minor	$30	$50	$70	Costs are for the salary of the identified expert over the period of time anticipated for resolution	1.5	2.0	3.0		5%	25%	$3	$13	$19	7.50	0.10	0.50	0.75
I&T	3.08.04	IT-036	Optical Engineering Expertise	IF complications arise in the I&T optical characterization phase that are too complicated for the nominally designated I&T sustained Optical Engineer, THEN additional "expert" resources may be required for resolution of those complications.	Bond	I&T	28-Nov-17	3	2	3	1	7.0	Minor	Study	Optical Expert	1) Expert resources have been identified for mitigation of refrigeration related issues.		Hold	11/2017 initial entry	CD-4		5/1/2018	3	2	3	1	7.0	Minor	$30	$50	$70	Costs are for the salary of the identified expert over the period of time anticipated for resolution	1.5	2.0	3.0		5%	25%	$3	$13	$19	7.50	0.10	0.50	0.75
CCD	3.03.02.02	CCD-001	Sensor Delivery	IF the vendors do not deliver sensors according to the LSST high level project schedule, THEN a schedule delay will be incurred, as well as additional costs associated with a prolonging production cycle. This risk is independent from CAM-049 and asusmes that science grade sensors can be used.	Wahl	Procure	17-Apr-17	2	3	4	2	7.0	Minor	Proto	Sensor prototype program	7/7/15 No Change Mitigation 1 (baseline): Start production of sensors as soon as possible and keep 2 vendors for the first article and 1st production lot. Downselect before the award of 2nd production lot. Mitigation 2 (baseline): Move from a homogeneous to a heterogeneous focal plane, if the production vendor(s) is late on delivery. Project will have from two vendors (60% of focal plane from 1st article and 1st lot run). Mitigation 3 (not implemeted yet in residual risk): Close the cryostat with less than 21 science rafts and install the remainder at SLAC after camera integration and test. 7 more months to finish the integration of sensors. Assumes 1 month to open up the cryostat and install the remaining rafts (depends on how many). Summit camera verification testing is scheduled. No draw on float to CD-4. Mitigation 4 (not implemeted yet in residual risk): close the cryostat with less than 21 science rafts and install them on the summit prior to camera verification testing. 24 more months to finish the integration of sensors Reduce CD-4 float from 26 months to 17 months. Mitigation 5 (not implemented or budgeted yet): a) Purchase additional sensors from the best performing vendor at the time (worse case is listed in residual risk using most expensive vendor) b) Purchase 8 spicing (colored) M13 scaled sensors		Working	5/11/18: ITL Sensor count: 81 Science, 44 Reserve, 38 Eng, 0 TBD; 81 candidate ITL die left to process; e2v has delivered 21 Science SLIN1 sensors; 3 more await shipping; delivered will likely be earlier that deadlines specified in contract 4/16/18: ITL Sensor count: 70 Science, 39 Reserve, 35 Eng, 2 TBD; e2v has delivered 21 Science SLIN1 sensors; delivered will likely be earlier that deadlines specified in contract 3/21/18: ITL sensor count 61 Science, 33 Reserve, 30 Eng, e2v has started delivering SLIN1 sensors early: 5 new sensors from new wafer run now at BNL. 2/20/2018: ITL sensor count: 56 Science, 27 Reserve, 3 TBD. ITL now starting 16 sensors/week and will work past contract end date to process all LSST raw material. 12/2017: The count of ITL sensors to date is: 45 Science sensors, 23 Reserve sensors. The production rate in October through early Nov. of Science sensors has fallen to 1.7/week. The reserve production rate is 1.0/wk. 11/2017: 77 e2v sensors in hand: 7x9=63 are on RTMs; 10 are assigned to CR as GS; 2 are currently unassigned Science sensors, 1 is a M12 Reserve sensor and 1 has been damaged. In addition to ITL RTM#1 there are 39 "Science" grade and 19 "Reserve" grade sensors at BNL. Production rate at ITL for sensors started in September and early October (5 week period) is 2.4 Science and 0.6 Reserve per week.	CD-4	7/1/2018	1/15/2018	2	3	4	2	7.0	Minor	$0	$300	$600	5/2018: We have 82 e2v and 81 ITL science grade sensors and 44 reserve ITL. 4/2018: We have 78 e2v and 77 ITL science grade sensors and 38 reserve ITL. There are enough sensors with reserve to build the focal plane. e2v delivery is ahead of schedule. Cost exposure at this point is the potential standing army cost of science raft team if e2v is delayed. Assumes 2 month delay at e2v at $150K/month nominal and 4 months worse case delays at e2v. 2/2018: We have enough sensors in hand from ITL, including reserve that with completion of SLIN-001 from e2v, the threshold KPP can be met. Mixed race in	0.0	3.0	4.0		1%	5%	$3	$15	$55	9.00	0.03	0.15	0.20
Cryo	3.06.04.06	Cryo-056	Refrigeration System and Camera subsystem interface	IF the refrigeration system interface with the camera subsystems are not clearly defined, THEN unplanned work will need to be added	Callen			3	2	2	2	7.0	Minor			1. Meet regularly with camera subsystems 2. Keep ICDs updates current		Working				5/1/2017	3	2	2	2	7.0	Minor	$30	$150	$200		0.5	1.5	1.5		5%	25%	$8	$38	$54	20.75	0.08	0.38	0.38
Cryo	3.06.04.06	Cryo-045	Cold & Cryo Geometry test	Oil could stay trapped in the camera due to gravity and require major telescope plumbing changes if test not completed in time	Callen			3	2	2	2	7.0	Minor			Perform geometry elevation testing.		Working	3/2018: We will learn from pathfinder. 2/2018: Based on elevation drape test, new cold system condensing system has two oil separator. Cryo system was tested with 8 feet elevation; cryo system is a lower risk than the cold system. 4/2017: Cold system elevation testing planned for the week of April 24th. The result should be available early May. 3/2017: Plan to perform elevation testing. Risk List: CRYO-024. The TMA geometry has changed and we now have to address the elevation and rotation only. This test would simulate some of the draftpes and verifies that the oil return to the compressor in the new geometry will be sufficient to avoid damage to the compressors .	CD-4	5/29/2017	3	2	2	2	7.0	Minor	$30	$100	$200		0.5	1.5	1.5		5%	25%	$5	$25	$42	15.75	0.08	0.38	0.38

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Opt	3.05.02	Opt-003	Filter delivery	IF filter set delivery is delayed due to government military priorities at the vendor, as there are few qualified vendors and there is limited large chamber equipment THEN Camera final test and calibration will slip impacting camera delivery to the Observatory	Wolfe	Procure	15-May-18	2	3	4	2	7.0	Minor	Study	Filter schedule contingency	Schedule Contingency Management - Plan 3 month schedule margin between filter delivery & final filter need date for Camera Integration - Maintain a contingency option that would allow last filter assemblies to be integrated at the Observatory level of integration		Working	5/2018: Chamber has been assigned to LSST for almost 2 years with only one 6 week interuption but not for military needs. 6/2017: fab and coating vendors have not indicated any concerns during time working with them. 6/04/2015: Successful filter FDR completed, filters are on track 9/2011: Schedule margin planned in schedule (3 months) - 4/2011: Post Mitigation probability expected to be insignificant, residual late filer assembly deliveries moderate/high Cost/Schedule/Performance impact to final Observatory Integration	CD-4		12/1/2018	1	2	3	2	2.7	Insignificant	$30	$100	$200	Cost is incentive to vendor	1.5	3.0	3.0	This is beyond the current schedule float.	0%	1%	$0	$1	$8	0.53	0.00	0.03	0.03
CB&M	3.06.02.02	CBM-001	Shutter dynamics	IF Shutter blades vibrate excessively or drive system has dead-band THEN it will not meet exposure knowledge req's or cause damage to neighboring components	Nordby	Fab	17-Oct-17	3	2	2	2	7.0	Minor	Proto	Shutter prototype	0.5. Build and test motor and capstan test units to test inertia matching, belt tension, and motor config's (COMPLETE) 1. Build and test shutter blade prototype to test static deflection and modes of blade assembly (COMPLETE); 2. Test drive system test unit to characterize dynamics of the feedback control loop (COMPLETE); 3. Build and test Shutter prototype to test dynamics of shutter with the drive system		Working	5/2017: Changed to stepper motor drives which negates need for modifying tuning with gravity angle; finalizing drive train proto with final control system 8/2016: Modified drive train design to provide means to deal with any instabilities or vibration (no more cantilevered drive shaft; better inertia matched, option to add gear box) 3/2016: BCR approved and additional drive train motor testing is underway and implemented into prototype work; expect inertia-matching test to be complete by early May 11/2015: Developed additional scope to Drive Train proto testing; LCN and BCR in process 5/2015: Blade and drive train prototypes underway 4/2014: Blade analysis shows vibration should not be an issue; updated prototype plan advances drive system test unit earlier to retire this risk 8/2013: changed to stiffer 2-blade design; proto work not started yet 4/2010: Initial testing shows that blades vibrate; re-design waiting personnel availability 3/2011: blade vibration problem solved; servo motor position encoder does not exhibit deadband, to be verified.	10/1/2017	10/1/2017	10/1/2018	2	1	1	1	2.3	Insignificant	$0	$30	$30		0.0	0.0	0.5		1%	5%	$0	$2	$4	0.75	0.00	0.00	0.03
Cryo	3.06.05	Cryo-060	Making up Utility Trunk vacuum and refrig lines	IF a vacuum knife-edge flange or refrig VCR fitting is damaged during mate-up of the UT, THEN a repair will be needed to fix the leak	Callen			3	2	2	2	7.0	Minor			1-Protect edges during assembly process. 2-Use VCR gaskets with clips. 3 - Provide adequate room for the final mate-up of refrig lines 4-Design fixturing to reduce risk during mate/de-mate		Working					3	1	1	1	3.5	Insignificant	$0	$30	$30		0.0	0.5	0.5		5%	25%	$2	$8	$10	3.75	0.03	0.13	0.13
EXCH	3.06.03	EXCH-029	Auto Changer particulate generation	IF the Auto Changer sheds particles during operation, THEN L2 and Filters throughput will be degraded	Karst	I&T	16-Jun-17	3	2	2	2	7.0	Minor	Proto	Auto Changer life test prototype	Test materials and lubricants in test units, then run Auto Changer prototype in clean environment and collect fall-out		Hold	02/2018 : The Long duration test with particule measurement is planned in 2019. 06/2017 : Comtamination test is planned on April 2018 for 4 Months 01/2017 : Comtamination test is planned on January 2018 9/2016 : The end of the Contamination test planned in December 2017 5/2015: The contamination test is planned to be done in march 2017 4/2013: The Single Filter Test is working; waiting on particulate generation spec from CCP 5/2011: Tests are planned in the Test Plan documents for the Single Filter Test and the Full Scale Prototype. 8/2010: waiting funds	EXCH Proto test	9/1/2019	10/1/2018	3	1	1	1	3.5	Insignificant	$0	$0	$30	offset cost	0.0	0.0	0.5		5%	25%	$0	$0	$3	0.75	0.00	0.00	0.13
Opt	3.05.02	Opt-030	Filter O-ring compression set	IF the filter o-ring takes a larger compression set than estimated, THEN the filter may move outside of its positional requirements and potential damage the Filter.	Wolfe	Dev	15-Jan-16	3	2	1	3	7.0	Minor	Study	Design and Testing	By design, chose o-ring material and compression for expected environmental conditions. Complete thermal testing to evaluate o-ring performance. Design such that impact is limited if o-ring compression set occurs and can be replaced without damaging Filter.		Working	Design presented at FDR in June 2015. Demonstration Unit passed survivability testing conditions.	FDR		9/1/2018	3	1	1	2	4.5	Insignificant	$0	$0	$30		0.0	0.0	0.5		5%	25%	$0	$0	$3	0.75	0.00	0.00	0.13
I&T	3.08.03	IT-009	Raft to Raft Cross-talk	IF the raft-to-raft cross-talk exceeds specifications THEN I&T will need to diagnose the source of cross-talk and support mitigation strategies	Roodman	I&T	1-Jul-16	3	2	2	2	7.0	Minor	Study	Cross-talk testing	1) Budget time/effort in Cryostat level I&T, when the first 2 rafts are integrated, for cross-talk study & mitigation. See ITC14774. (PLANNED)		Hold	6/2015: Moved status to holding. Will hold until raft testing is completed. 4/2014: I&T will need to be prepared to evaluate RAFT to RAFT cross talk as soon as second RAFT is installed. If cross talk in excess of requirement is found a working group between I&T and SR will need to form quickly to find a solution. Tied to ITC14774.	ITC00450		9/1/2018	3	2	2	2	7.0	Minor	$30	$100	$200	Cost to conduct additonal testing and software based mitigations	0.5	1.0	1.5	Schedule to conduct additonal testing and software based mitigations	5%	25%	$5	$25	$42	15.75	0.05	0.25	0.38
Opt	3.05.03	Opt-005	L1-L2 lens mount	IF local stresses imparted by the mount design distort the lenses, THEN distortion would impact image quality and possibly damage the lens.	Wolfe	Fab	15-Jan-16	2	2	5	2	6.7	Minor	Anal	Mount design development	Work through flexure and mount details with opto-mechanical engineer from LLNL Provide LSST design to vendor during the procurement design phase. Engage vendor with fixed -price build contract to meet wavefront requirements when optics are mounted		Working	7/2014: Vendor is under fixed-price design-build contract to meet wavefront L1-L2 wavefront specs when optics are integrated into mounts 2/2013: Delta CoDR design reduces the stresses by 15.7% at zenith, 55.7% at horizon and 62.3% at horizon rotated 90 degrees. probability reduced from a 2 to a 1 9/2011: Analyzed lens stresses and impact on image quality not an issue on current design. Opto-mech engineer identified. Investigating mount options with Heritage.	L1-L2 FDR		7/1/2018	1	2	5	2	3.3	Insignificant	$30	$200	$200	redesign and fabrication of new flexures	6.0	6.0	24.0	If mounts needed to be redesigned during integration phase at vendor, it could take a year to implement change and re-integrate. Expected value is 6 months beyond current 120 days of float.	0%	1%	$0	$2	$12	0.86	0.00	0.06	0.24
Sci Rft	3.04.01.06	Srft-076	Raft damage during shipment to SLAC	IF the Science Raft is mishandled during shipment from BNL to SLAC, THEN significant damage could occure.	Wahl	Procure	26-Mar-17	2	4	3	1	6.7	Minor	Proto	Use Enhanced Shipping Methods	Use enhanced shipping methods that offer the greatest protection throughout the shipment of the Raft form BNL to SLAC. FedEx offers shipping methods that are costly yet offer the appropriate level of protection for expensive and delicate packages like the Science Raft.		Accepted	7/17/17 ETU2 was delivered to SLAC on 7/10 using the enhanced shipping methods described below and all went well. The liklihood for damage when using the enhanced shipping methods is very low. 4/14/17 A BCR was approved in March 2017, which provided the necessary budget to use "FedEx Custome Critical Surface Expedite" as the shipping method for all RTM shipments going formward. ETU1 was shipped using this method and the shipment went quite well as expected. The cost per shipment is expensive but the service FedEx provides reduces the chances of damage, which is reflected in this months Risk Registry (probability lowered from 3 to 2). 3/26/17 As we prepare to ship ETU1, we have decided to use a service provided by FedEx that offers greater protection relative to standard shipping methods. "FedEx Custom Critical Surface Expedite" offers point-to-point delivery using a dedicated truck with air-ride suspension and GPS tracking. The RTM Shipping Container would be loaded on the truck at BNL using BNL riggers and removed at SLAC using authorized personnel. This would be a much better solution relative to standard shipping methods, where there would be no guarantees in terms of the quality of handling at other facilities including trucking facilities and airports.	RTM 22	12/15/2018	3/31/2017	2	4	3	1	6.7	Minor	$1,500	$2,000	$10,000	4/15/17 The mitigation plan has been adopted. 3/26/17 Even if the mitigation strategy is adopted, there is always the opportunity for damage to occur due to vehicle accidents. There is also the possibility the vehicle and/or package could be stolen. Both of these scenarios are difficult to prevent but should be noted nonetheless.	1.5	2.0	3.0	4/15/17 The mitigation plan has been adopted. 3/26/17 Even if the mitigation strategy is adopted, there is always the opportunity for damage to occur due to vehicle accidents. There is also the possibility the vehicle and/or package could be stolen. Both of these scenarios are difficult to prevent but should be noted nonetheless.	1%	5%	$20	$100	$614	97.50	0.02	0.10	0.15
Cam	3.01	CAM-043	LDRD addition tax, directed change	IF the government mandates that SLAC must charge LDRD tax to MIE projects, THEN the project cost will increase	Riot	Mng	15-Jul-15	2	4	3	1	6.7	Minor	Study	Grandfather	FPD is working on getting an exemption since we are past CD-2. This could be considered a directed change and the TPC may need to increase to cover this unanticpated increase.		Working	11/2/2015 Per verbal from the SLAC controller we have received the exception 7/2015: FPD is working on getting this exemption in writing.	CD-4	6/1/2020	10/1/2018	2	3	3	1	5.7	Minor	$810	$891	$1,053	5/2018: 5.5% on 16.2M labor/M&S to go at SLAC (as of 4/2018) 3/2018: 5.5% on 20.9M labor/M&S to go at SLAC (as of 3/2018)	1.5	2.0	3.0		1%	5%	$9	$45	$157	27.14	0.02	0.10	0.15
Opt	3.05.04	Opt-027	L3 damaged during fabrication/assembly	IF the Lens is damaged during grinding (or later phase) THEN the substrate will have to be reworked (or replaced).	Wolfe	Fab	17-Feb-16	2	2	4	3	6.7	Minor	Anal	Vendor Oversight	Monitor vendor setups and processes. Ensure proper equipment is in place and all actions are taken according to agreed upon work and handling protocols		Working	Will be part of contract oversight process. Consider having L3 Vendor make a spare lens or alternative mitigation. 5/2015: Plan to discuss at vendor kick-off meeting and follow-up prior to L3 blank procurement. 10/2015: This is a low risk. 2-3 month duration for blank material procurement vs. $50-60K for a spare blank. Recommend not procuring spare blank during Phase 2. 9/2016: Vendor has started the lens fabrication process.	6/1/2018		10/1/2016	1	2	4	3	3.3	Insignificant	$30	$200	$200	Assume $200K total impact	3.0	3.0	6.0	This is beyond the current 80 days of float.	0%	1%	$0	$2	$12	0.86	0.00	0.03	0.06
Opt	3.05.02	Opt-023	Filter Position	IF the filter frame does not hold the optic in place to required levels THEN the image quality may suffer	Wolfe	I&T	5-Jun-15	2	2	3	4	6.7	Minor	Anal	Evaluate and update design	Frame design to be analyzied and revised to ensure filters are securely held		Working	3/2015: Design to be presented at FDR. Analysis shows positional tolerance met Filter frame design is ongoing	7/10/2015		2/1/2019	1	2	3	3	3.0	Insignificant	$30	$42	$200		1.5	3.0	3.0		0%	1%	$0	$0	$5	0.33	0.00	0.03	0.03
Opt	3.05.04	Opt-032	L3 Lens vacuum seal	IF the L3 lens vacuum seal is damaged (and leaks) and needs to be repalced, THEN the camera will not be avalable during this duration.	Wolfe	I&T	6-Jul-15	2	2	2	5	6.7	Minor	ETU	Design and Testing	Design sealing interface so that the o-rings are robust and replaceable. Thermal cycle test to demonstrate seal is robust. Test to show lens can be removed/replaced and meet vaccum requirements to help with selection process and provide competetion. Ship to vendor for repair if ever needed.		Working	7/2015: Working on final design with vendor			10/1/2018	1	2	2	5	3.3	Insignificant	$30	$30	$200		0.5	1.5	1.5		0%	1%	$0	$0	$5	0.29	0.00	0.02	0.02

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
CB&M	3.06.01.02	CBM-049	Camera body part detailing	IF the current budget for drafting part and assembly drawings is not adequate, THEN the camera body will not be delivered with a complete drawing set	Nordby	Fab	14-Feb-17	4	2	1	1	6.7	Minor	Study	Provide additional designer personnel	1. Add funding for a completely documented set of drawings (ON HOLD--additional funding not approved) 2. Add designer time to fully document the considerably more complex final design (COMPLETE)		Hold	2/2017: Designer started in late January to help with detailing; this is covered by existing budget and the approved EAC. 11/2016: Risk added in connection with reducing EAC estimate associated with this added work	Camera Body Delivery	1/1/2018	10/1/2017	4	2	1	1	6.7	Minor	$30	$150	$200	Spend additional designer resources to complete documentation of camera body parts and assemblies	0.0	0.5	0.5		25%	67%	$38	$101	$85	63.63	0.13	0.34	0.34
Cryo	3.06.04.06	Cryo-025	Refrigeration: Contamination Control	IF adequate and deployable contamination control processes cannot be devloped and employed THEN the refrigerators will plug or freeze and not provide the required cooling.	langton / schindler	ETU	1-Sep-15	4	2	1	1	6.7	Minor	ETU	cleanlines processing and control	develop appropriate cleaning, handling, assembly and operations processes to ensure system remains free of priticulates and condensables. Use lessons learned from refrigeration development vendor where applicable. Develop, test and deploy processes required for unique aspects of LSST system. Develop appropriate traveler and pedigree documentation, PPE and training requirements and operations protocols, test in developement and I&T system deployment efforts and operations activities.		Working	3/2018: The process is unders control: implement filter dryer bake out before installation. 2/2018: We will resolve the issue with Pathfinder. 3/2017: Based on experience, the current procedure are sufficient. There is still risk because of the plumbing we receive. 11-2016: ETC is needed to determine if the current budget will support contamination procedures. Purely a cost and schedule risk. 10-2016: additional budget may be required to meet the current procedures for contamination control. Additional equipment and steps are needed to ensure proper cleanliness of the system. 9-2015: considerable efforts and development in constructino techniques to provide clean and contamination free hardware / assemblies. 5-2105: no new assessment 2-2015: continued efforts in testing indicate that reasonable and practical measures are easily implimented to significantly reduce the possibility of contamination overall, and to reduce the risk to critical eelements in the system should foreign matter find its way into the system. 10-2014: continue to debvelop and test method for decontaminating and dessicating system, methods in place for fabricatin of system hardware, and assembly of system to achieve required level of cleanliness. 4-2014: Visited and discussed fabrication procedures / processing with vendor. Procured system flush hardware. Implementing UHV derived fabrication, assembly and processing protocols. Establishing work process / work traveler documentation requirements and component QA	CD-4	5/1/2016	6/1/2018	2	1	1	1	2.3	Insignificant	$0	$30	$30	1Assumes risks are not mitigated in ETU phase and continued effort is required during I&T and at the observatory	0.0	0.5	0.5		1%	5%	$0	$2	$4	0.75	0.01	0.03	0.03
Cryo	3.06.04.06	Cryo-054	Refrigeration Cryo Compressor modules	IF the compressor module delivery from MMR takes longer than estimated, THEN, the refrigeration system delivery to I&T will be delayed.	Callen			3	1	3	2	6.5	Minor			1. Test R404 compressor as early as possible 2. Place order with MMR as soon as the design is mature		Working	5/2018: MMR completed the first article cryo compressor module. 1/2018: R404 compressor testing completed at MMR and ready for pick-up. 7/2017: Compressor SOW sent to MMR for RFQ. Updated and releasing SOW based on MMR response. Waiting for an updated RFQ.			12/1/2017	3	1	2	2	5.5	Minor	$0	$0	$30		0.5	1.5	1.5		5%	25%	$0	$0	$3	0.75	0.08	0.38	0.38
EXCH	3.06.03	EXCH-046	Filter Change Time	If some filter change steps take a too long time, then the system will not meet the filter change time specification, forcing modification of the driving device and modification of the control/command architecture	Karst	ETU	16-Jun-17	3	1	3	2	6.5	Minor	Proto	Exchange system prototype	Measure and define the step duration as soon possible for the actions as weel as for the C/C communication. Optimize the sequences with simultaneous actions, increase as much as possible the communication speed. Refine the time distribution for each step. Then Validate or Negociate the total allocated filter change time.		Working	05/2018 : The combined test will start in May 2018. The FCS also need to be optimized. 02/2018 : The combined test will start in April 2018 11/2017 : Need more work with the Filter Control System, and with the combined test. 09/2017 : The Auto Changer needs more tuning for the filter travel and the on-line clamping. Data on time change will be privided in November 2017 07/2017 : After the improvement of the hardware, the software needs to be be updated, the final result is expected in September 2017 06/2017 : Because of the implementation of a sensor for the filter approach at the on-line position, the travel time will increase. The time estimate has to be done 05/2017: The last test with the FCS on a sequence "travel+On Line Clamp closing" is now 16 seconds, this is just the allocated time without margin and without exceeded time. Other improvements are expected with the FCS. 04/2017 : The last tuning of the motor controller allows an higher speed without high misalignment. Tests are expected in the next weeks 03/2017 : The filter travel fron the on-line position to the Hand-off position is currently 11 s for 9s allocated.	EXCH Proto test	July 18	11/1/2017	1	1	1	1	1.2	Insignificant	$0	$0	$30		0.0	0.0	1.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.02
Cam	3.01	CAM-016	IN2P3 Exchange System Labor Funding	IF IN2P3 labor for exchange system is not adequately funded to support their planned participation, THEN management reserve or descope will be needed to cover the shortfall	Riot	Mng	15-Jul-15	3	3	1	1	6.5	Minor	Study	Obtain Commit.	1) Identify and obtain commitments from all Laboratories for labor, and documented in CRADA (DONE with ICRADA)		Working	5/2018: Filter exchange system full prototype shows high maturity 9/2017: ICRADA in place and recent MRR shows IN2P3 is funded to support the plan 5/2016: risk partially realized with request for structural analysis supprot from the project. This cost was reviewed under LCN-1560. Risk still remains as more effort may be needed to support filter exchange work. 11/2015 Provide labor to IN2P. (mitigation not funded) 11/2013: Visited IN2P3 labs and attended PDR for the exchange system. Staff identified and progress is proceeding well. 9/2011: All required staff is identified and working.	CD-3	10/1/2018	1/1/2018	3	3	1	1	6.5	Minor	$200	$300	$1,500	Rough estimte for labor supporting assemby and test of the filter exchange system.	0.0	0.5	0.5		5%	25%	$15	$75	$203	72.50	0.03	0.13	0.13
Cam	3.01	CAM-030	Shop Rate Changes or Structures	IF shop rates increase above escalation within SLAC, THEN resulting -CV's could force de-scopes or draw on management reserves.	Riot	Mng	15-Jul-15	3	3	1	1	6.5	Minor	Study	Manage Contingency	Manage contingency on a regular basis to minimize impact of cost increase		Working	11/2017: update with work to go of $6M 10/14: This risk has been realized. The PMCS rates for FY 15 have increased above inflation. PM has a regular meeting with the CFO and will ensure that we are engaged in the stakeholder discussion moving forward. 9/14: decreased probability based on committment by CFO to force labor bands to stay on budget 4/9/14: Split risks by lab and shop rate. Met with the SLAC Director and Deputy Director. Project will receive a memo stating that they do not anticipate our indirect rates changing. 9/2013: SLAC shop rates have increased and resulted on a significant draw on contingency.	CD-4	6/1/2020	10/1/2017	3	2	1	1	5.0	Insignificant	$0	$70	$280	5/2018: SLAC shop labor to go as of 2/2018 (METS resources, TID resources, PMCS resources) is 2.8M. Assume 0%, 2.5% and 10% maximum. Escalation is already in plan 2/2018: SLAC shop labor to go as of 2/2018 (METS resources, TID resources, PMCS resources) is 3.3M. Assume 0%, 2.5% and 10% maximum. Escalation is already in plan	0.0	0.0	0.5		5%	25%	$4	$18	$40	14.00	0.00	0.00	0.13
Cam	3.01	CAM-046	Sci Raft Scope schedule	If Science Raft cannot complete RTMs within the planned schedule due to lack of sensors THEN the project will draw on schedule contingency or will need to reduce scope	Riot	Mng	30-Jun-16	2	3	3	2	6.3	Minor		none	1 - Monitor schedule progress with weekly milestones for sensor vendors and science raft team (DONE) 2 - Ensure corner raft can be assembled by Science Raft team to keep team working (budgeted at ~110K) 3 - Ensure the Science Raft team build the mockup rafts to keep the team working (budgeted at ~51K now DONE) 4 - Use science reserve sensors when needed (43 sensors to date available) 5 - Develop a backup TS7 dewar at BNL to accelerate testing turn-around (DONE wiht TS7-3) 6 - Develop a backup TS7 dewar at SLAC to accelerate IR2 testing turn-around (Planned with corner raft TS7) 7 - Review science impact of assembling some fraction of sensors with degraded noise (DONE with LPM-262 memo)		Working	5/2018: LPM-262 and LCA-16456 have reduce the risk of this significantly. The corner raft dewar as extra capacity is the last mitigation to contain schedule 4/2018: opportunity not taken due to cost trade study. no change in risk. 3/2018: review opportunity to add an extra TS7 dewar at SLAC 2/2018: RTM2, RTM3, RTM4, RTM5 accepted and delivered. ITL sensor issue may cause problems. So no changes. 12/2017: RTM4 accepted 11/2017: RTM2 delivered to I&T. Enough sensors are in hand for up to RTM15 when reserve are included 10/2017: scienc eraft team working on the mockup rafts. Current sensor flow is sufficient to keep the team working. 07/2017: risk maintained although it does appear that 9 sensors will be available from ITL in time to limit standing army cost in August 2017 05/2017: 20 baseplates in hand. The last 4 are expected by end of May. probability reduced 02/2017: no change current shcedule is holding but sensor delivery is reducing available schedule float 01/2017: schedule is being monitored weekly with intermediate milestones. Scheudle is currently holding. 9/2016: Probabilty increased given reduction in float of the ETUs 6/2016 Risk entered	CD-4	10/1/2018	11/1/2018	2	3	2	2	5.7	Minor	$200	$200	$400	~$200K BNL labor monthly rate for 1 month delays. Max is two month delays on science raft activities.	0.5	0.5	1.5	half a month impact on camera with Corner raft Dewar catchup mitigation pending	1%	5%	$2	$10	$41	7.00	0.01	0.03	0.08
Cam	3.01	CAM-001	SLAC Indirect cost change	IF indirect costs increase within SLAC Labor, THEN resulting -CV's could force de-scopes or draw on contingency.	Riot	Mng	15-Jul-15	2	3	4	1	6.3	Minor	Study	Manage Contingency	Manage contingency on a regular basis to minimize impact of cost increase		Working	4/9/14: Split risks by lab and shop rate. Met with the SLAC Director and Deputy Director. Project will receive a memo stating that they do not anticipate our indirect rates changing. 3/12/14: Applied and have received reduced SLAC overhead for the project. Moved optics procurements to LLNL from SLAC. This will result in an increase in the indirect cost. Negotiating with LLNL for a reduced rate. 9/2011: Obtained commitments and projections on indirect costs from all institutions. 9/2013: SLAC indirect rates have increased and resulted on a significant draw on contingency.	CD-4	6/1/2020	10/1/2017	2	3	4	1	6.3	Minor	$200	$268	$375	5/2018: 2.5% change in rate on $10.7M of SLAC labor to go (as of 4/2018). 3.5% maximum 3/2018: 2.5% change in rate on $13.2M of SLAC labor to go (as of 3/2018). 3.5% maximum	3.0	6.0	6.0		1%	5%	$3	$13	$48	8.22	0.06	0.30	0.30

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Cam	3.01	CAM-041	Standing Army Costs additional 6 months (delayed 1 year)	If the camera is late on elements (filters, rafts), THEN standing army costs will be needed to complete the project	Riot	Mng	15-Jul-15	2	3	4	1	6.3	Minor	Study	Standing Army	Manage contingency relative to float.		Working	7/2015: updated assessment 10/2014: Entry. Project has 24 months of float	CD-4	6/1/2020	4/1/2019	2	3	4	1	6.3	Minor	$600	$1,200	$2,400	$200K/month standing army. Assumes this isn't impacting I&T. Captured in other risks.	3.0	6.0	6.0	This assumes 6 additional months, to get final hardware directly to summit	1%	5%	$12	$60	$231	39.00	0.06	0.30	0.30
Cam	3.01	CAM-011	BNL lab re-prioritization	IF BNL re-prioritizes work, lack of cosmic frontiers physics group could drive dropping sensor work, THEN unfinished work would delay critical path schedule	Riot	Mng	15-Jul-15	2	3	4	1	6.3	Minor	Study	Shift work within collaboration	Ensure BNL is committed to LSST. Move work to other labs and universities within the collaboration as needed to fill gaps		Working	2/2018: some contributed labor at BNL was reduced but cost stayed within the EAC. No change. 11/2013: Cosmic Frontier group has tie with Andrei 5/2013: Working with OHEP to fund PI at BNL. Testing at Harvard is in place and currently ramping up LPNHE's testing. 9/2011: MOU in place. Duplicate sensor testing at IN2P3 and Purdue exists. 4/2011: On-going effort to manage work by camera management team	CD-4	6/1/2020	10/1/2016	2	2	4	1	5.3	Minor	$30	$47	$94	BNL Contributed labor is 2.15 FTE in FY17, and then 0.75FTE in FY18-FY19. $250K/year assumption. Assumes the 0.75FTE in the late half of FY18 is lost as max, and Q4 as nominal.	3.0	3.0	6.0		1%	5%	$0	$2	$9	1.56	0.03	0.15	0.30
Cryo	3.06.05	Cryo-062	UT Temperature Stability	IF the components in UT generate more heat than planned, THEN UT will not meet the camera temperature requirement.	Callen			3	2	1	2	6.0	Minor			1 - Design the cooling system with margin on dispated power. 2 - Tracke development of system hardware in UT		Working					2	2	1	2	4.0	Insignificant	$30	$50	$200		0.0	0.5	0.5		1%	5%	$1	$3	$13	2.15	0.01	0.03	0.03
Cryo	3.06.04.06	Cryo-028	Refrigeration: refrigerant cost	IF: we cannot limit quantity and base rate for refrigerant THEN we will encounter unsustainable operations cost for the mixed refrigeration system.	langton / schindler	ETU	1-Sep-15	3	2	1	2	6.0	Minor	ETU	system ops and volume reduction	investigate design and operations plans that minimize refrigerant loss during maintenance functions, refrigerant recovery and reuse Total or Isolation system volume reduction through design modifications.		Working	3/2017: We identified some maintence activities that require complete recharge of refrigerant. 9-2015: efforts to limit refrigerant losses during system modifications and improved recovery techniques demonstrated There are options for recovery, oil separation and reuse we have not pursued yet. There are possibilities for reducing volume that have not been discussed project wide. There are operations details that, if modified or clarified, will have potential to reduce loss of refrigerant, these will be explored in detail in future project meetings.	CD-4	5/1/2016	6/1/2018	2	2	1	2	4.0	Insignificant	$30	$50	$200	Assumes risks are not mitigated in ETU phase and continued effort is required during I&T and at the observatory	0.0		0.5		1%	5%	$1	$3	$13	2.15	0.00	0.00	0.03
SE	3.02.01	SE-033	Contamination coordination support	IF more material requires contamination testing coordination for qualification than anticipated THEN additonal budget will be required	Riot	Design	11-May-18	3	2	1	2	6.0	Minor	Study	Monitor qualification requests	Monitor qualification requests (DONE) Provide contamination support (Giulia Lanza) (DONE) Ensure test are required by reviewing existing data that could lead to the item being on the approved list (DONE); Complete Contam Ctl Plan revision to include camera body (DONE); Work with sub-systems to follow best engineering practices and use approved material as much as possible (IN PROCESS)		Working	5/2018: RGA testing on-going, largely covered by subsystem fabrication costs; matl's qual testing is nearly complete, while staying in budget 11/2017: Completed revision of Contam Ctl Plan to include components in camera volume; continuing test program to qualify new matl's as needed 09/2017: LCN-1935 responds to partial realization of this risks and covers more FY18 support 07/2017: It is apprent that more contamination support will be needed in FY18. Probability almost certain 05/2016: risk creation	CD-4		7/1/2018	3	2	1	2	6.0	Minor	$30	$70	$150	more contamination support for FY19 (Giulia at 20% for FY19)	0.0	0.0	0.5		5%	25%	$4	$18	$30	11.50	0.00	0.00	0.13
SE	3.02.02	SE-019	EMI/EMC	IF obs-level analysis identifies EMI/EMC testing or design mods are needed, THEN camera component re-design may be needed	Hascall	Design	10-Sep-14	3	2	1	2	6.0	Minor	Study	Identfy problem areas	Assess design and possible EMI/EMC problem areas; define and perform interference tests if needed (done)		Accepted	2/2015: Best effort and best practice will be followed per the camera shielding and grounding plan (LCA-278). Requirements are captured. Closing. 8/2014: discussed at Phoenix2014 mtg--no plans to levy EMI test req's on camera; 3/2013: starting write-up on possible areas of susceptibility for review by Obs SE	CD-2 Review		10/1/2019	3	2	1	2	6.0	Minor	$30	$150	$200	historical residual cost	0.0	0.5	0.5		5%	25%	$8	$38	$54	20.75	0.03	0.13	0.13
CCS	3.07.01	CCS-002	Insufficient personnel	If CCS D&D lacks sufficient personnel, THEN some camera subsystem development will run behind schedule or over budget, and will not be tested properly before deployment.	Johnson	ETU	22-May-15	3	2	1	2	6.0	Minor	Anal	Personnel mitigation	Develop an integrated funding profile that includes schedule dependencies. Add personnel to the team as needed.		Working	Baseline schedule was completely updated for CD-2 and is monitored and monthly EVMS meetings 5/15/2018 Insufficient manpower remains a risk. Related issues that impact this are delays in other subsystems which require us to keep manpower on board longer, incremental increases in features requested by other subsystems (CCS-010), and lack of contributed manpower (CCS-026). Current mitigations continue to be appropriate.	PSR		8/1/2017	2	3	1	2	5.0	Insignificant	$200	$500	$1,500	mitigation reduces probability	0.0	0.0	0.5	Plan is to spend enough money to not delay the project	1%	5%	$5	$25	$113	18.50	0.00	0.00	0.03
Cryo	3.06.05	Cryo-061	UT Mass	IF the total mass is greater than requirements, THEN more engineering time and complexity will be needed to reduce the weight.	Callen			3	2	2	1	6.0	Minor			1. Complete light weighting of UT structure 2. Update structural FEA		Working					2	2	2	2	4.7	Insignificant	$30	$50	$200		0.5	1.0	1.5		1%	5%	$1	$3	$13	2.15	0.01	0.05	0.08
CB&M	3.06.02.02	CBM-039	Shutter staycelar volume	IF all shutter components cannot stay within its tight stayclear volume, THEN growth in the volume may require re-work of Exch System or L3 assembly designs	Nordby	I&T	17-Oct-17	3	2	2	1	6.0	Minor	Study	Detailed modeling of all Shutter components	Fully flesh out preliminary design details for all shutter components, including controlers, cabling, cooling, to assess if volume margins to stayclear are adequate		Working	5/2017: Modifying stayclear to fit FDR design; motor and Elec Box stayclears fit around auto changer and L1-L2 stayclears and FDR hardware designs for both are smaller then earlier 8/2016: Finalizing new motor and cabling stayclear; these appear to accommodate other stayclears with no required mods to auto changer or L1-L2 stayclears 3/2016: Investigating drive train changes that affect motor stayclear region; ECD: Sep 2016 11/2015: Initiated CBM-046 to capture shutter electronics packaging; shutter blade prototype work underway 7/2015: Need to delete HCU, PLC and elec system design and spec additional volume in camera body for crate 5/2015: Blade flatness is an issue that could impact cost 3/2015: size and number of components for control and protection look like they will not fit in available volume; need to spec out this system and define an adjacent volume for housing electronics; 5/2014: 2-blade design and stayclear evaluated and adequate clearances confirmed; 2/2014: 2-blade prelim design completed; shutter stayclear simplified and increassed where available; prelim design shows adequate margin to all stayclears; 8/2013: risk opened after envelope volume has already been increased once	FDR	5/1/2017	6/1/2019	2	1	1	1	2.3	Insignificant	$0	$30	$30	Tweak hardware design locally to resolve detailed problems if they arise	0.0	0.0	0.5		1%	5%	$0	$2	$4	0.75	0.00	0.00	0.03
CB&M	3.06.02.02	CBM-040	Shutter insertion/ extraction	IF the Shutter cannot be safely inserted and extracted from the camera, then camera downtime due to shutter servicing needs could increase	Nordby	I&T	17-Oct-17	3	2	2	1	6.0	Minor	Study	Detailed modeling of extraction rail	Flesh out design details for rail system		Working	5/2017: FDR design of shutter and camera body show that shutter extraction fits, but involves considerable additional work, jeopardizing the 4-6 hour turn-around 2/2017: Extraction rail design completed and ready for review and check 8/2016: Separate elec and motor envelopes have been defined; this ensures that extraction volume is well smaller than availble room between struts; updated extraction rail design concept is being developed 3/2016: invetigating electronics envelope and accessibility; need better definition on servicing time 11/2015: Waiting on updated TMA solid model to evaluate extraction crane hook envelope and height 5/2015: waiting final design effort 4/2014: insertion rail design in-work for PDR shutter design; 2/2014: updated prelim design is more compact and easier to install/extract 8/2013: risk identified; working to complete preliminary design of shutter to assess risk details and work up design for handling model	9/1/2018	9/1/2018	9/1/2018	2	1	1	1	2.3	Insignificant	$0	$0	$30	Live with decreased reliability if shutter extraction proves too hazardous to do on the telescope	0.0	0.0	0.5		1%	5%	$0	$0	$1	0.15	0.00	0.00	0.03
DAQ	3.07.02.02	DAQ-010	Manpower	If the DAQ has underestimated the necessary the required manpower or suffers the loss of a team member, then the DAQ then the schedule will increase at additional cost.	Huffer	Dev	27-Oct-15	3	2	2	1	6.0	Minor	Study	Identfy alternative personnel	1-Identify other personnel with experience the RCE platform that could quickly come up to speed. 2-Continue to track DAQ schedule and if necessary add personnel.		Working	5/15/2018: Work remains on schedule. 12/2017: Work remains on schedule. Nov 2017 DAQ is on schedule. Version 2 deployed to IR2 and Brookhaven 7/13/2017 Version 2 is finished and is available for deployment 6/1/2017 Version 2 has slipped another month 5/2017: Version 2 has slipped another month 4/2017: Version 2 has slipped 1 month 11/2016: On schedule for version 2. 3/2016: Delivery of version 1 (which used peak manpower) reduces the probability of this risk being realized 1/2016. Stefano arrived mid January. Manpower sufficient 11/2015. Progress on version 1 gives confidence that we understand the required manpower. 10/22/2015 Sergio has been added to bring the FTE count up to the budget. 7/14/15 : Reassess progress at scheduled delivery of DAQ System V1.0 to CCS. Alternative personnel have been identified	Version 3 delivery	10/1/2016	10/1/2016	1	2	2	1	2.0	Insignificant	$30	$45	$200	Assumes schedule is falling behind and need additional manpower for 1-2 mos to get back on track.	0.5	1.0	1.5		0%	1%	$0	$0	$5	0.34	0.00	0.01	0.02

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Current Assessment: Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
									Impact of Risk				Exposure Level										Impact of Risk				Exposure Level																			
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Cryo	3.06.04.05	Cryo-012	Cryostat vacuum system	IF we cannot develop an integrated - robust vacuum pumping system THEN we may not be able to meet the contaminant control requirements	Schindler	Design	4-Jun-15	3	2	2	1	6.0	Minor	Proto	Develop vac system design	Assess gas load and transport, evaluate material outgassing and effects, select pump types, sizes, quantities. Test and analyze effects on actual sensors, adjust requirements accordingly.		Working	6-2016: New designs have provided additonal space for more getter. Final selection of pumps and instrumentation TBC. Material selction complete, processing requirements TBF 5-2015: advances in material test, material selections, and vacuum system design , coupled with improved definition of requirements reduces overall risk probability. 2-2015: no significant change in risk exposure. Shrouds redesigned and simplified. Conductance barriers simplified and improved, new monte carlo analysis in progress. continue interating configuration of evaporable getters, tests scheduled. 10-2014: complete significant analysis of vacuum system and are incorporating "lessons learned" into final design of thermal shrounds and getter pump assemblies, we have a firm understanding of the croystat vacuum side of the risk and continue to work with other subsystems on material test and effects to close the lopp and finalize risk / mitigations 8-2014: ongoing analysis of vacuum clean processes (plasma cleaning) and molecualr transport probabilites use monte carlo simulations of the cryostat assembly3/2014: Reassessment / CCB review of increased throughput degradation requirement, which drives NVR gas load limits to FPA, in process to increase allowable outgass specs and gas transport probabilities, Limited progress on contamination / outgassing tests to date. Progress made on Conductance barrier shroud design. improved design of charcoal allows more quantity in focal plane region. New shrouding and getter geometry needs to be input to GEANT / MOLFLOW montecarlo programs for evaluation. Enhanced material tests / methods are in process to evaluate camera representative materials and processing in	CD-4	12/1/2015	10/1/2017	2	2	2	1	4.0	Insignificant	$30	$35	$200	Assumes the system performance impact is accepted	0.5	1.0	1.5		1%	5%	$0	$2	$12	1.85	0.01	0.05	0.08
CB&M	3.06.02.02	CBM-046	Shutter elec enclosure volume	IF we cannot package and locate the shutter electronics in the available space in the camera volume THEN we would need to either develop custom designs or move components	Nordby	Design	17-Oct-17	3	2	2	1	6.0	Minor	Study	CAD layout of updated packaging	1. Finalize control electronics (COMPLETE); 2. Lay out components and develop package concept; develop purge system cooling (COPMPLETE); 3. Fit in camera volume and route cables; work around auto changer components		Working	5/2017: ID'd final control components; specing power components; elec volume and cabling routing have been identified 8/2016: completing prelim design of elec housing and IDD stayclear 3/2016: Components selected; elec enclosure desgin developed and being detailed now; cable routing clarified w/ routing work in process 11/2015: Selecting components with motor manufacturers; developing packaging options	CD-4	10/1/2018	10/1/2018	6/1/2019	2	2	1	1	3.3	Insignificant	$30	$150	$200		0.0	0.5	0.5		1%	5%	$2	$8	$24	4.15	0.01	0.03	0.03
Cryo	3.06.05	Cryo-076	LED lights in Auxiliary Electronics	IF the LED lights from the Auxiliary Electronic components leaks through the Utility Trunk, THEN cost increase and schedule delay will incurr to reduce the stray light	Callen			3	2	2	1	6.0	Minor			Design UT doors and skins with no straight path Add shielding gasket to edges		Working				2	2	1	1	3.3	Insignificant	$30	$50	$200	Thiis should be Auxiliary electronics's risk, but UT might need to enhance doors and skins design to further reduce stray light	0.0	0.5	0.5		1%	5%	$1	$3	$13	2.15	0.01	0.03	0.03
I&T	3.08.03	IT-034	Thermal interface changes	IF thermal interfaces need to be improved after Raft insertion THEN de-insertion and retrofit will be needed	Bond	I&T	6-Nov-17	2	2	4	2	6.0	Minor	Study	Raft thermal interface changes	1) Additional testing at SLAC has been identified in an effort to better characterize the thermal properties of the rafts.		Working	11/2017 initial entry	CD-4		11/1/2018	2	2	4	2	6.0	Minor	$30	$150	$200	Cost for this issue are likely limited to the standing army costs associated with the increase in schedule.	1.0	3.0	6.0		1%	5%	$2	$8	$24	4.15	0.03	0.15	0.30
Cam	3.01	CAM-048	eTraveler support	IF eTraveler experiences significant issues in FY18 onward THEN the project will need to find resources to address the issue and delay will be incurred	Riot	Mng	14-Dec-17	3	2	2	1	6.0	Minor		Maintain contributed labor available	1) Maintain some level of contributed labor (Anders Borgland) - DONE		Accepted	12/2017: risk created due to on project support by CCS team of eTra veler ending in January 2018. Risk has been accepted by the project. Mitigation is avaiklability of Anders to help as possible.	CD-4	6/1/2020	1/15/2018	3	2	2	1	6.0	Minor	$30	$100	$200	rouh estimate for labor needed to address major eTraveler issue (30% FTE)	0.5	1.0	1.5	1 month delay expected if issue happens during I&T	5%	25%	$5	$25	$42	15.75	0.05	0.25	0.38
Cryo	3.06.04.06	Cryo-080	Refrigeration Individual System Testing	IF the refrigeration testing takes longer than planned, THEN additional resources and time will be required to complete the testing.				4	1	2	1	6.0	Minor			1) Check flow rate before hand 2) Check capillary flowrate beforehand		Working				2	1	1	1	2.3	Insignificant	$0	$20	$30		0.0	0.5	0.5		1%	5%	$0	$1	$3	0.55	0.01	0.03	0.03
I&T	3.08.04	IT-011	Vacuum Pump down time	IF the time required for the thermo-vac cycle is underestimated - i.e. if extra time is required for water removal, THEN additional time will be required for pump-down and there will be an impact on the schedule.	Bond	I&T	1-Dec-15	5	1	1	1	5.8	Minor	Study	Hot Nitrogen Purge	1) The cryostat will be flooded / purged with hot nitriogen (50 deg C) prior to pumpdown. (PLANNED) 2) The design allows for aditional pumping capacity to be added		Working	12/2015 - Risk identified. 4/2016 - Alternative options for heating cryostat are being explored.	CD-4		9/1/2018	3	1	1	1	3.5	Insignificant	$0	$25	$30	Cost of adding additonal ion pumps	0.0	0.5	0.5	delay for installing additonal pumps	5%	25%	$1	$6	$9	3.25	0.03	0.13	0.13
I&T	3.08.02	IT-026	REB power	IF REB boards in single RAFT test stand (TS7) are connected with wrong power connector (differs from direct to REB) THEN RAFT damage could occur.	Reil	I&T	17-Mar-17	2	3	3	1	5.7	Minor	Study	Strict prcodeures	1) Strict power on procedures to be documented (DONE with LCA-10064) 2) Test with ETU1 and ETU2 before testing with production RTM (DONE)		Working	Inial Entry March 2017 - Discussed as item to resolve for aliveness review on March 24.		4/1/2017	10/1/2016	2	3	3	1	5.7	Minor	$200	$700	$1,500	Cost of repairing damaged RTM	1.5	3.0	3.0		1%	5%	$7	$35	$135	22.50	0.03	0.15	0.15
Sci Rft	3.04.01.02.02	Srft-011	Operation of hold-down mechanism	IF the hold-down cam cannot be reliably used, THEN the raft could be damaged during integration	Bellavia	I&T	5-Jun-15	2	3	3	1	5.7	Minor	ETU	Design rework and ETU study	Past Entry: Modify design to include locking feature, revised design will be tested with ETU prototype.		Working	5/15/18 As of May 2018, two Mechanical Test Rafts (MTRs) have been successfully installed in the Mock-Grid where the hold-downs were fully exercised with no issues observed. Providing successful results are obtained with the remaining 3 MTRs, this Risk will be closed (likely by July 2018). For now, the probability assignment will remain at "Unlikely" 9/11/17 The Hold-Down design was validated in the TS7 Cryostat many times (ETU1&2 and RTM1, 2, 3 & 4) with successful results obtained in terms of good retention by way of the spring-force. Mechanical Rafts will be constructed for I&T, which will confirm load transfer aspects of the Hold-Down design. 10/18/16 The Hold-Down design was presented at the D-FDR/MRR in September 2016 and was accepted. The design is complete and preparations for Raft production is underway. 8/5/16 The hold-down design was reviewed at the D-FDR and changes were requested. The design has been updated to reflect the action items that were assigned. The design will be reviewed at the SR MRR in late August 2016. 12/1/15 The RTM Hold-down design has been redesigned and will be reviewed at the SR MRR in August 2016 9/2011:	Successful integration of Mechanical Rafts into the mock-Grid (Cell)	1/15/2018	8/1/2018	1	3	3	1	2.8	Insignificant	$200	$200	$1,500		1.5	3.0	3.0		0%	1%	$0	$2	$33	2.08	0.00	0.03	0.03
I&T	3.08.03	IT-040	Late Refrigeration Failure	IF the refrigeration system fails during the ETU phase THEN ETU's, L3 Flat, OTMs, and Feedthroughs will be contaminated or damaged	Bond	I&T	16-Mar-18	2	3	3	1	5.7	Minor	Study	Hx individual testing	1) Heat exchangers will be leak checked individually prior to acceptance by I&T. 2) OTM / Feedthrough installing occurs in minimal increments.		Working	Mar 19/2018: Created to address risks added during heat exchanger delay schedule re-organization.		11/1/2018	8/1/2018	2	3	3	1	5.7	Minor	$200	$250	$1,000	1) $200k for L3 cleaning 2) $25 for OTM cleaning / RGAs 3) $25 for Feedthroughs 4) Leak repair cost up to $1M	1.5	2.0	3.0	Estimate of two months for repair	1%	5%	$3	$13	$68	11.00	0.02	0.10	0.15

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment: Impact of Risk					Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
CCD	3.03.02.02	CCD-005	ITL Sensor Delivery Rate	IF the primary vendor cannot deliver 3 Science+Reserve Grade sensors per week, which is a function of the number of sensors that start the Hybridization-Oxidation-Thinning-Coating-Packaging process flow and the yield, THEN there will be a cost impact. This yield is independent of noise issues covered under risk CAM-049.	Markiewicz	Procure	11-Nov-16	2	3	2	2	5.7	Minor	Anal	increase oversight	1) Monitor vendor closely (add a dedicated sensor procurement manager) to understand yield issues (Done, To markiewicz has joined the project) 2) Award additonal long lead material (partial Phase C) to mitigate yield drop (Done in May 2017) 3) Award SLIN-002 for additonal long lead at E2V (Done in June 2017) 4) Reserve funding for SLIN-003 for fabrication of SLIN-002 long leads (Done in May 2017) 5) Award SLIN-003 in October 2017 to secure 30 more e2v sensors (approved) 6) De-scope to threshold KPP to recover schedule (partially done with LPM-262)		Working	5/11/18: ITL delivery rate increased to ~3.8 Science & Reserve sensors/week 4/16/18: ITL is delivering ~2.8 Science+Reserve sensors/week; it is likely that this rate will be maintained or increased during the last 6 weeks of production (that ends June 30). 3/21/18: Yields of Shipped/Starts, Science/Shipped, Reserve/Shipped continue to be about 0.4, 0.51, 0.24, respectively. 2/20/18: ITL now starting 16 sensors/week. Deliveries from these starts have only now begun to appear. 12/18/17: The production rate in October through early Nov. of Science sensors has fallen to 1.7/week. The reserve production rate is 1.0/wk. The 8 starts/week is being maintained.. 11/27/17: Production rate at ITL for sensors started in September and early October (5 week period) is 2.4 Science and 0.6 Reserve per week. The 8 starts/week is being maintained. 9/11/17: Rewrite risk description to reflect required number of science sensors delivered per week rather than the number of sensors whose processing begins each week. 7/13/17: ITL=Vendor 2 has JUST (7/10/17) gone from 4 starts/week to 8 starts week. Need to see what the time required for processing is for these batches. Need to		6/1/2018	1/15/2018	2	3	2	2	5.7	Minor	$0	$300	$600	5/2018: It is becoming clearer that ITL production will end June 30, 2018 4/2018: with e2v SLIN-003, and quantities in hand, the only cost residual impact is to carry ITL a few more month. Assume 2 month nominal 4 months worst case at $150k/month 10/2017: opportunity is removed with approval of SLIN-003 award. Phase C was partially awarded ($500K) so worst case is $1.25M, nominal is another $500K. Cost would be to award Phase C-2 ($1.75M) for yield decrease from 30% to 20%. Nominal is ~half of remaining of phase C. There is an opportunity for a $1.5M return to	0.5	1.0	1.5	10/2017 update: camera delivery date pushed by 2 month so schedule impact is reduced. To 1 month. Assumes we reduce testing	1%	5%	$3	$15	$55	9.00	0.01	0.05	0.08
CCS	3.07.01.02.10	CCS-021	eLog support from FNAL	If FNAL decides to terminate support for the eLOG, THEN an alternate system is needed or we take on the support	Johnson	Design	22-May-15	2	3	2	2	5.7	Minor	Anal	Maintain good working relations with eLog developers	Evaluate which improvements/features will be needed. Get users to exercise the eLog. Try to incorporate as soon as possible the features that need to operate with the eTraveler. Present desired feature list to FNAL as early as possible.		Working	We continue to receive support and new releases from the FNAL team. We hold meeting to discuss our requirements as needed. 5/15/2018 New developments for the Fermilab logbook have ceased, but they continue to provide support for existing users. We have begun to make more extensive use of SLACK, and integrated SLACK with the logbook to reduce our dependency on the loa book.	I&T		3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$30		0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
I&T	3.08.03	IT-041	Combined Refrigeration & vacuum Testing	IF the partially tested (as delivered) CCS control system cannot operate Vacuum and Refrigeration systems properly with no issues then I&T will have to diagnose and repair (cost and schedule hit).	Bond	I&T	16-Mar-18	3	1	3	1	5.5	Minor	Study	Vac Sys Testing	1) Vacuum system will be independantly tested prior to delivery to I&T		Working	Mar 19/2018: Created to address risks added during heat exchanger delay schedule re-organization.		11/1/2018	8/1/2018	3	1	3	1	5.5	Minor	$0	$10	$30	Standing army costs capture in CAMERA level risk	1.5	2.0	3.0	Estimate of two months for debugging and repair	5%	25%	$1	$3	$5	1.75	0.10	0.50	0.75
Sci Rft	3.04.01.03	Srft-029	significant board related xtalk	IF crosstalk on board is large THEN crosstalk requirement will not be met	Van Berg	Design	5-Jun-15	2	2	3	2	5.3	Minor	Study		Identify problem area and redesign board.		Working	5/15/18 I&T at SLAC is in the process of verifying crosstalk in integrated RTMs. Requirements are met thus far. If similar results are obtained after the next few Rafts, it is likely this Risk will be closed. 9/11/17 Crosstalk measurements have been performed on ITL & e2v Rafts. Based on analysis performed by P. Doherty & P. OConnor, Rafts constructed with ITL & e2v Sensors show little signs of crosstalk. Further testing is planned at SLAC, which will provide a more detailed assessment. 5/16/17 Crosstalk measurements were performed on RTM1, which is constructed with ITL Sensors. Based on an analysis performed by P. Doherty, it apears the ITL Rafts does not show signs of significant cross-talk. The same cross-talk measurements will be performed on RTM2, which is constructed with e2v Sensors. 4/15/17 Crosstalk measurements was obtained at TS8 using RTM1. The measurements were made just prior to submitting this month's Risk Regestry update so the results of the measurements cannot be spoken to just yet. The results of the measurements will be included in next months Risk Registry. 11/16/16	Crosstalk measurement results at SLAC (performed by I&T)	8/15/2018	3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$30		0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
EXCH	3.06.03	EXCH-017	Carousel ring gear failure	IF the Carousel ring gear fails from pitting, scuffing, or breakage, THEN Carousel rotation capability would be lost, significantly impacting observing	Karst	Fab	16-Jan-17	2	2	3	2	5.3	Minor	Proto	Ring gear load and life test	Design and analyze ring gear with adequate safety margin; sub-contract thorough analysis by expert; life test full scale prototype		Working	02/2018 : The Long duration test with particule measurement is planned in 2019. 09/2017 : The first result of the long duration test is expected in July2018 01/2017 : The first result of the long duration test is expected in February 2018. 10/2015 : The results with positive margins have been provided in October 2015. 5/2015: The results of the updated calculation will be provided in October 2015. The life test result is planned for march 2017. 10/2012: Margin on the ring gear higher than on the pinion 3/2011: safety margins calculated (OK), all details in the analysis report. Will be life tested, cf. EXCH-020 7/2010: initial design nearly complete; specs sent to technological expert center (CETIM) for est/subcontract 4/2010: initial design nearly complete; spec being written for outside design	EXCH Proto test	9/1/2019	3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$30	offset cost	0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
EXCH	3.06.03	EXCH-030	Auto Changer lifetime and wear	IF Auto Changer components wear, THEN we will need more down time to troubleshoot and repair	Karst	I&T	16-Jun-17	2	2	3	2	5.3	Minor	Proto	Auto Changer life test prototype	Test materials and lubricants in test units, then run Auto Changer prototype to establish wear rates and maintenance intervals		Hold	02/2018 : The Long duration test with particule measurement is planned in 2019. 06/2017 : The test is postponed in April 2018 01/2017 : The test is postponed in January 2018 9/2016 : The end of the Contamination test planned in December 2017 5/2015: The long duration test is planned for march 2017. 2/2015: The component fatigue calculations are in progress. Some components are already identified to be replaced during the scheduled shutdown. 4/2013: The Single Filter Test which is running will provide data for several components 8/2010: waiting funds 3/2011: Preliminary fatigue analysis shows a plausible maintenance schedule to meet up-time requirements	EXCH Proto test	9/1/2019	3/1/2020	1	1	2	1	1.5	Insignificant	$0	$0	$30	offset cost	0.5	1.0	1.5		0%	1%	$0	$0	$0	0.03	0.00	0.01	0.02
Opt	3.05.03	Opt-035	L1-L2 Internal Volume Contamination	IF the L1-L2 internal volume is excessively contaiminated by the composite structure material shedding particulates THEN L1-L2 will need to be disassembled and the internal volume cleaned.	Wolfe	Op	20-Aug-15	2	2	2	3	5.3	Minor	Anal	Design and Testing	Vendor will manufacture and clean material consistent with processes that have met much tigher cleanliness requirements compared to the L1-L2 Assembly requirements. L1-L2 Assembly designed to allow disassembly and cleaning. Vendor will provide tooling and proceedures to disassemble.		Working	8/20/15: Vendor has presented a design consistent with mitigation at the 90% review.	FDR		8/1/2019	2	2	2	2	4.7	Insignificant	$30	$60	$200	Nov 2016 EAC included spare parts to addess the disassembly/reassembly. Costs expected to disassemble twice over the life of operation	0.5	1.0	1.5	Expected two weeks duration (each cleaning) for cleaning in the cleanroom on the summit.	1%	5%	$1	$3	$14	2.35	0.01	0.05	0.08
Cam	3.01	CAM-045	Sci Raft scope budget	If Science Raft continues to have difficulties completing their scope for the planned budget, THEN the project will draw on contingency or need to reduce scope	Riot	Mng	30-Jun-16	2	3	1	2	5.0	Insignificant		None	1) Hold BNL to EAC value. 2) Perform yearly comprehensive EAC (DONE for FY17 and FY18)		Working	05/2018: Team has recovered. Probability to not hold the EAC is low. 02/2018: Team appears to have demonstrated that the work can be done with junior folks, Probability reduced for both current and residual assesment. 11/2017: FY18 EAC is holding and schedule is on track 07/2017: current trend is maintained. No change to risk. 06/2017: Science Raft team is over performning compared to EAC. This risk is reduced. 01/2017: no change. science raft team EVMS performance indexs have not showed signs of recovery yet. 11/2016: Updated residual to capture the full cost and remove the fencing off as mitigation 10/2016: Risk realized with an estimated draw on contingency of $300K. Additional draw could be up to $500K more. Mitigation to fence off $300K leaves the residual risk is 200K 9/2016: Risk is expected to be partially realized upon completion of the ETC exercise from the science Raft subsystem. 6/2016 Risk entered	CD-4	11/1/2018	8/1/2017	2	3	1	2	5.0	Insignificant	$200	$250	$500	05/2018: no change 04/2018: no changes 03/2018: Scope of work remaining since estimate has been reduced by half so dollar estimate have been reduced accordingly Estimate of $500K in case the junior staff current plan requires the funding level of senior staff.	0.0	0.0	0.5		1%	5%	$3	$13	$50	8.50	0.00	0.00	0.03

LSST Camera Risk Registry

SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Probability	Cost (Impact of Risk)	Schd	Perf	Score (Exposure Level)	Current Exposure
I&T	3.08.04	IT-012	IR2 Logistics	IF IR2 shared space with LZ is not easily and effectivily managed and facilitated, THEN possible "near critical path" schedule impacts may be incurred.	Bond	I&T	18-Apr-16	3	2	1	1	5.0	Insignificant
SE	3.02.02	SE-028	Back end stayclear and interface issues	IF accommodation for access during integration and serving is not adequately accommodated for in the CAD design of the carousel, cryostat back end, purge system inlet/out routing, and Aux Elec crate access and cable routing in the UT, THEN integration of components into the UT and integration of the Cryostat/UT may take more time than planned, with more risk of problems and damage	Nordby	Design	11-May-18	3	2	1	1	5.0	Insignificant
CCS	3.07.01.02	CCS-009	Maintainability	IF technology choices become obsolete, or documentation is inadequate THEN the system cannot be properly maintained.	Johnson	I&T	22-May-15	2	3	1	2	5.0	Insignificant
CB&M	3.06.01.02	CBM-041	Purge system design	IF the purge system does not adequately remove heat and control camera body temperature to follow the dome temp, THEN we will not meet our ICD req and dome seeing may be worsened	Nordby	Design	17-Oct-17	3	2	1	1	5.0	Insignificant
CB&M	3.06.02.02	CBM-028	Shutter particulate generation	IF the Shutter generates particles that shed onto the filters, THEN contamination and throughput req's would not be met	Nordby	I&T	17-Oct-17	3	2	1	1	5.0	Insignificant
Opt	3.05.02	Opt-040	Aeroglaze Coating	IF the aeroglaze coating application does not meet requirements, THEN schedule and cost impacts will be incurred.	Wolfe	Fab	11-Feb-16	3	2	1	1	5.0	Insignificant
Opt	3.05.02	Opt-041	Interface Compliance	IF the Filter Assembly does not meet the complex/tight interface requirements, THEN schedule and cost impacts will be incurred.	Wolfe	Fab	17-Feb-16	3	2	1	1	5.0	Insignificant
SE	3.02.02	SE-030	Observatory IT infrastructure	IF the observatory does not establish clear responsibility for IT infrastructure in (base and summit facilities) including account management, authorization, firewall policies and monitoring, hardware and operating system standards, common logging, patching and upgrading, cyber-security policies and implementation THEN the camera team may have to invent ad-hoc solutions to these services, and in a worse case scenario then rework much of that if standards are established after we have already implemented our own solutions.	Johnson	Design	22-May-15	3	2	1	1	5.0	Insignificant
EXCH	3.06.03	EXCH-044	Back Flange Delivery	If the Back Flange is not available in time at LPNHE, the Carousel assembly in France will be delayed and the Carousel integration in the Camera will be delayed.	Karst	Fab	16-Jun-17	2	2	3	1	4.7	Insignificant

SS ID	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone (Target Retirement)	Date (Target Retirement)	Date Will Occur
IT-012	Study	IR2 Coordination Meetings	1) An I&T representative will meet weekly/biweekly to coordinate with the LZ team regarding possible upcoming logistical interactions or issues (IN PROGRESS).		Working	04/2016 - Risk Identified - Team coordination meetings are now scheduled.	CD-4		6/1/2017
SE-028	Study	Complete Carousel design; finalize interfaces and assy plans	1. Complete Carousel and interface designs and hold Carousel dFDR (Exch); (COMPLETE) 2. Complete purge system supply and return manifold and plumbing design, routing, and connect/disconnect plans (CB&S); (COMPLETE) 3.. Develop design of crates for Aux Elec, vac electronics (COMPLETE); 4. Develop integrated scheme for routing and connection/disconnecting cables and plumbing (COMPLETE); 5. Complete mock-up and agree on cryostat/UT connection and cable disconnect plans (IN PROCESS)		Working	5/2018: Mock-up work to be re-started after quad box delivery in Jul, 2018, as part of finalizing UT design; 3/2018: Mock-up completion on hold, waiting for Quad Box loading to be completed; ECD May, 2018 1/2018: Feedthrough, cryo vac cabling, and cabling to camera body are in work; expect mock-up completion in Feb-Mar. 11/2017: UT mock-up and FDR completed; risk reduced; propose closure after mock-up work is complete 7/2017: UT PDR was successful and UT mockup is in progress to assess this. Probability reduced. 2/2017: UT design continues to not be settled 1/2017: Purge system supply and return mainifold and plumbing design, routing and connect/disconnect plans completed 12/2015: Carousel dFDR complete; Derek Chow hired to handle U.T. and electronics packaging 7/2015: Carousel working towards 10/2015 dFDR; purge system flow calcs complete and manifold re-sizing underway	Cryostat IRR	5/1/2018	4/1/2019
CCS-009	Proto	Choose long-lived technologies.	The CCS design has incorporated technology that is near the beginning, not the end of its life cycle. The CCS architecture can accommodate replacement of software components.		Working	We continue to monitor the health of the libraries we use, and update to newer versions, or altnerative libraries as appropriate. 5/15/2018 Technology choices continue to be well supported, with the possible exception of Java Swing graphical user interface library. We periodically review all libraries in use and expect this to continue during I&T, commissioning and operations.	PSR		3/1/2020
CBM-041	Anal	Purge system analysis	Fianlize design and analysis of purge system ability to remove heat and maintain stable skin temperature		Working	8/2016: Final design and analysis shows that design has margin against heat loads and can track to dome temperature 3/2016: Completed conceptual design of Mech Purge and purge cabinet in U.T. that removes heat with modest temp control; still working on finalizing design and on Cam Volume purge 11/2015: New M.E. hired and started work on purge cabinet design in U.T. 7/2015: Purge thermal analysis complete; Exch System power increased, with commensurate increase in purge mass flow; not clear (yet) of a system to meet these reqs will fit in the U.T. 5/2015: updated purge system analysis underway 3/2015: updated power budget shows avg power is lower; T&S ICD changed to reduce temp rate-of-change, so thermal reqs have eased; room in UT for purge crate is getting tight, which complicates design; 9/2014: purge system proto was descoped, so prob of problems has gone up; need to work with T&S team to re-frame the ICD spec to make it match IQ error needs 2/2014: Shutter and cam body air-cooling system developed; further work needed on L3 and Exch Sys cooling; 10/2013: design not started; Exch Sys avg power draw is increasing ~50% which puts much higher cooling load on purge system 8/2013: purge system design not yet started due to personnel prioritization	9/1/2016	9/1/2016	4/1/2018
CBM-028	Proto	Shutter prototype	1. Test drive system test unit to select low-shedding belt, lubricants, bearings, and test wipers; 2. Test Shutter life and contamination test prototype to characterize wear and develop methods to minimize contamination		Working	5/2017: >100 miles on Delrin tip material; Igus and other materials ready for testing; identified clean room belt matl (incl in FDR baseline design), but have not spec'd out test methods 8/2016: prototype build is underway 11/2015: Identified improved belt material for lower shedding; plan to test both candidate materials 5/2015: Test units underway; design modified to add considerable shrouding to trap particulates 5/2014: updated development plan to incude early test unit for mitigating much of this risk early 2/2014: updated prelim design includes cover plates and wipers to contain any particulates that are generated 4/2013: proto work not started due to funding constraints 4/2010: Not started	10/1/2017	10/1/2017	10/1/2018
Opt-040	Proto	Testing	Plan test samples and will also test on Evaluation Frames prior to production.		Working	2/2016: Developing test samples to verify application and cleanliness requirements.		6/1/2017	11/1/2017
Opt-041	Proto	Testing	Evaluation Frames will be tested by the Filter Exchange Team and I&T prior to production build.		Working	2/2016: Evaluation frames will be assembly starting summer 2016 per P6 schedule.		6/1/2017	8/1/2019
SE-030	Study	Coordinate with Observatory	Maintain coordination with the Observatory to support infrastructure design and understand status of implementation plan		Accepted	10/2017 Still no clear plan for responsitibily for IT infrastructure. The probability that the camera will need to provide our own support for code installation and maintenance has increased. 3/2015 Observatory has now accepted responsibility for IT operations. We are expecting to be consulted on planing for this over the coming year. 10/2015: A "tiger team" has been formed at the observatory level to address these issues. Johnson and Huffer are members. 8/2015: transferred from CCS-024 as it impacts CCS and DAQ. A web page has been set up for discussion on this topic at https://confluence.lsstcorp.org/x/pAACAQ 7/2015: Responsibility for IT infrastructure has been assigned to the telescope headed by German Schumacher. He has prepared a document describing expected functionality, and is looking for manpower to implement the plan. We expect to work closely with the telescope team to ensure our requirements are met as infrastructure is developed.		12/1/2016	1/1/2018
EXCH-044	Proto	Back Flange Developement Plan	Identify the duration for the Back Flange Fabrication and delivery in France. Define the fabrication starting date in order to be ready for the Carousel Assembly in September 2017. In case of Delay for the real Back Flange, schedule the update of the Dummy Back Flange design. Order the second Dummy back Flange at the latest in October 2016.		Working	05/2018 : The Back Flange has not been delivered. It is expected in May 2018. 03/2018 : Preshit review in April 2018, The delivery is planned in May 2018. 02/2018 : The Back flange availability is scheduled for April 2018 at Paris. Then the carousel integration is postponed to December 2018. 01/2018 : The Camera Body schedule is under revision. The Back Flange availability is TBD. 08/2016 : A new plan has been defined with the delivery of the final Back Flange at Paris around September 2017. The Carousel will be assembled and tested in Paris and then it will be shipped on the Back flange to SLAC. This allowed to save integration time at SLAC and to reduce technical risks. 04/2016 : At this time, the plan for the Back flange doesn't schedule the Back Flange delivery in time. We started to schedule the update of the 2nd dummy Back Flange in September 2016. But this device is not yet founded and it will need more mounting and dismounting operations and probably more time for the final delivry date. 02/2016 : Martin Nordby doesn't confirm the Back Flange could be delivered in time for the final Carousel. In case we need a second Dummy back Flange, the decision must be taken the later in September 2016. 02/2016 : Initial Status	Carousel Procurement	June 18	3/1/2020

SS ID	Residual Risk: Post-Mitigation Assessment – Probability	Cost (Impact of Risk)	Schd	Perf	Score (Exposure Level)	Residual Exposure	Post-Mitigation Cost (k$) Min	Expect	Max	Comments	Post-Mitigation Delay (mo.) Min	Expect	Max	Comments
IT-012	2	2	2	1	4.0	Insignificant	$30	$50	$200		0.5	0.5	1.5	
SE-028	2	2	1	1	3.3	Insignificant	$30	$50	$200	Associated with additional personnel needed to complete integration if problems arose; design is finalized and all known issues addressed	0.0	0.5	0.5	Represents critical path delay if UT integration to cryostat takes longer than planned due to this risk
CCS-009	2	1	1	2	3.0	Insignificant	$0	$0	$30	Cost is operational	0.0	0.0	0.5	schedule impact is operational
CBM-041	2	1	1	1	2.3	Insignificant	$0	$30	$30	Mechanism purge temp gradients may be higher than preferred, requiring insulation on components	0.0	0.5	0.5	
CBM-028	2	1	1	1	2.3	Insignificant	$0	$8	$30	Filters and L2 would require more cleaning during operation	0.0	0.0	0.5	
Opt-040	2	2	1	1	3.3	Insignificant	$30	$50	$100	Additional resources (facility and manpower) required to implement aeroglaze coating to edge of Filters.	0.0		0.5	
Opt-041	2	2	1	1	3.3	Insignificant	$30	$60	$100	Assume as-built part compensation implmented to meet tight requirements. $10K/assembly	0.0		0.5	
SE-030	2	2	1	1	3.3	Insignificant	$30	$200	$200	Design and implement camera account management, authorization, firewall policies and monitoring, hardware and operating system standards, common logging, patching and upgrading, cyber-security policies and implementation. Assumes timely resolution at the observatory level (plan by CD-2)	0.0	0.0	0.5	Assumes funding for additional manpower so the schedule is not impacted
EXCH-044	1	1	1	1	1.2	Insignificant	$0	$0	$30		0.0	0.0	0.5	

SS ID	Residual Probability Min	Max	Contingent Cost (k$) Min prob* exp cost	Max prob* exp cost	std	Mean	Contingent Delay (mo.) Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
IT-012	1%	5%	$1	$3	$13	2.15	0.01	0.03	0.08
SE-028	1%	5%	$1	$3	$13	2.15	0.01	0.03	0.03
CCS-009	1%	5%	$0	$0	$1	0.15	0.00	0.00	0.03
CBM-041	1%	5%	$0	$2	$4	0.75	0.01	0.03	0.03
CBM-028	1%	5%	$0	$0	$2	0.31	0.00	0.00	0.03
Opt-040	1%	5%	$1	$3	$10	1.65	0.00	0.00	0.03
Opt-041	1%	5%	$1	$3	$11	1.85	0.00	0.00	0.03
SE-030	1%	5%	$2	$10	$30	5.15	0.00	0.00	0.03
EXCH-044	0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment: Risk Identification						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
							Impact of Risk					Exposure Level									Impact of Risk				Exposure Level																			
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Crnr Rft	3.04.02.03.02	Crft-014	Wavefront sensor limited acceptance testing	IF the waveformt sensor as received does not meet specification as tested after integration THEN schedule will be delayed as it will have to be de-integrated from the plate and replaced	Herrmann	Fab	5-Jun-15	2	2	3	1	4.7	Insignificant	Anal	Re-process the data collected by vendor and delievered at time of shipping	Vendor is expected to provide all test data. While sensor will NOT be re-tested by the LSST camera team, raw data from vendor will be re-processed to verify compliance (this was completed)		Accepted	8/2014: risk approved for creation at the 08/20/2014 risk review board 5/2015: data provided by vendor has been specified as part of the contract and approved at the FDR on 05/22/2015 9/2016: first article WFS are expetced to be characterized at Harvard to assess vendor data valitidty 01/2017: first article WFS is expected to start being tested by end of January 2017 02/2017; preliminary testing at Harvard of first article WFS shows performances as expected. More tetsing is needed to review read noise. 05/2017: current tetsing at Harvard looks good. Not completed yet. 09/2017: tested completed. Results were consistents. Risk now accepted.	CD-4	12/1/2017	11/1/2017	2	2	3	1	4.7	Insignificant	$30	$100	$200		1.5	2.0	3.0		1%	5%	$1	$5	$19	3.15	0.02	0.10	0.15
Sci Rft	3.04.01.03	Srft-052	Cross talk instability	IF crosstalk instability is higher than estimated (since it will not be measured at the CCD level) THEN crosstalk correction may not be possible	Stubbs	Design	5-Jun-15	2	2	1	3	4.7	Insignificant	Study		Will quantify crosstalk stability using ROAR. If stability is not of sufficient quality then examine the possibility of redesign and if not possible collect characterization data so DM can compensate		Working	5/15/18 A. Roodman is developing a test program at SLAC to further explore opportunities for cross-talk at the Raft level. Results of those tests are expected in the coming months. The probability assignment will remain at "Unlikely" until results are known. 9/11/17 Crosstalk measurements have been performed on ITL & e2v Rafts. Based on analysis performed by P. Doherty & P. OConnor, Rafts constructed with ITL & e2v Sensors show little signs of crosstalk. Further testing is planned at SLAC, which will provide a more detailed assessment. 5/16/17 Crosstalk measurements were performed on RTM1, which is constructed with ITL Sensors. Based on an analysis performed by P. Doherty, it apears the ITL Rafts does not show signs of significant cross-talk. The same cross-talk measurements will be performed on RTM2, which is constructed with e2v Sensors. If the same or similar results are reported for RTM2, the probability should be reduced to 2 (unlikely). 10/18/16 Crosstalk temperature dependence will be characterized with REB5 in ROAR. Temperature variation expected to be the main contributor to variability. 6/2015: Crosstalk measurements on ROAR has shown that crosstalk has high margin	Crosstalk measurement results at SLAC (performed by I&T)	2/15/2018	3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$30		0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
EXCH	3.06.03	EXCH-016	Carousel particulate generation	IF Carousel moving parts generate tiny wear particles or shed lubricant, THEN dust and lubricant could contaminate the optics	Karst	Fab	16-Jun-17	2	2	1	3	4.7	Insignificant	Study	Carousel contamination study	Investigate special lubricants for contamination-critical applications (wafer industry); Design cover to separate drive system from clean volume		Hold	02/2018 : The Long duration test with particule measurement is planned in 2019. 06/2017 : Results expected in July 2018 01/2017 : Results expected in February 2018 9/2016 : The end of the Contamination test planned in December 2017 5/2015: The contamination test is planned to be done in march 2017 2/2013: prelim design of the sealling started, driving and guiding dust retened by lubricant 4/2010: cover cannot seal completely contaminating area as carousel rotates; prelim design to be re-designed, but not vet started	EXCH FDR	9/1/2019	3/1/2020	1	1	1	2	1.5	Insignificant	$0	$0	$30	offset cost	0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
Sci Rft	3.04.01.02.02	Srft-044	I&T hold down force	IF I&T hold down force is not correct THEN RSA may not meet height requirements or RSA may fall off under loads in LCA-68	Bellavia	Design	5-Jun-15	2	2	2	2	4.7	Insignificant	Anal		Analysis and Modeling combined with a full RTM Prototype with a single grid bay (Not necessarily SiC)		Working	5/15/18 As of May 2018, 12 Rafts have been installed in the BNL TS7 Cryostats (some more than once) with each installation giving the appearance that the hold-downs are performing properly and delivering the appropriate hold-down force. I&T at SLAC has performed many installations in their Cryostats as well and they have confirmed proper hold down force by way of obtaining absolute height results of the RSA that were in good agreement with BNL's measurements. For this reason, this risk will be proposed for closure after having a discussion at the next Risk Review meeting scheduled for 5/16/18. 9/11/17 The Hold-Down design was validated in the TS7 Cryostat many times (ETU1&2 and RTM1, 2, 3 & 4) with successful results obtained in terms of good retention by way of the spring-force. Mechanical Rafts will be constructed for I&T, which will confirm load transfer aspects of the Hold-Down design. 1/17/2017 ETU1 was constructed using springs with spring-rates that were verified by the vendor. The ETU is currently being used to commission TS8. Once commissioning with ETU1 is complete, the hold-down force will be measured before the unit is shipped to SLAC.	Successful integration of Mechanical Rafts into the mock-Grid (Cell)	1/15/2018	3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$30		0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
Sci Rft	3.04.01.06	Srft-074	ITL Flex Cable loss of connectivity	IF the ITL Flex Cable looses connectivity with the CCD, THEN the CCD will be inoperable.	Wahl	Fab	8-Nov-16	2	2	2	2	4.7	Insignificant	Anal	Stake Connector	1) Stake Flex Cable connector to CCD using Stycast or some other staking method		Working	All ITL RSAs (including ETUs) have had the Flex Cables staked with Stycast (either in production or as an upgrade). The cable is secured very well and the risk of the cable becoming loos is extremely low. The probability is ranked as unlikely, which is appropriate. The Risk will be retired when all ITL Rafts have been constructed 7/17/17 Stycast was applied at the interface of the Flex Cable to CCD connection on ETU2 & RTM1. All future ITL Rafts will include a spring loaded clip that will allow the two Flex Cables to be Stycasted together and retained in the Base Plate by way of the spring-force offered by the clip. The new approach will avoid perminantly fixing the Flex Cable to the CCD as was done on ETU & RTM1. 4/15/17 Haller/Herrmann are developing a new Flex Cable design that is more robust. Once confidence is gained in terms of the cable's electro-mechanical performance, we will stake the cable to the CCD using Stycast. ETU2 and RTM1 will be reconstructed with these cables, where Stycast will be applied. 3/20/17 Now that we have experience constructing ETU1, ETU2 & RTM1, which have ITL Sensors, it is obvious we should fix the cable to the Sensor somehow. Stycast is a very good solution but the cable must be reliable and resist breakage before we permanently fix it to the CCD. The ITL Flex Cable is being re-engineered at SLAC to make it more robust	End of RTM production	12/30/2018	10/1/2016	2	1	1	2	3.0	Insignificant	$0	$0	$30	If the Flex Cable is properly staked, there is a very low probability for a loss of connectivity.	0.0	0.0	0.5	If the Flex Cable is properly staked, there is a very low probability for a loss of connectivity.	1%	5%	$0	$0	$1	0.15	0.00	0.00	0.03

LSST Camera Risk Registry

Risk Identification							Current Assessment							Mitigation Plan				Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																			
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Cmr Rft	3.04.02.03. 03	Crft-010	CCD Guide Sensor parallel shift time	If science raft CCD parallel shift time of 16us cannot be achieved, then 9Hz operation cannot be met or perfromances (read noise, CTE, etc ...) may be impacted.	Herrmann	ETU	5-Jun-15	2	2	2	2	4.7	Insignificant	Study	Test science raft CCD in guider readout mode	Run science raft CCD in guide readout mode (16us parallel shift time and fast serial shift) and assess performances in read noise and CTE (done, no more mitigations planned)		Accepted	3/2013: prototype CCDs in hand at Harvard and BNL. Harvard cannot test fast parrallel shift timing (limit tio no lower than 30us). BNL can read at the required speed but read noise cannot be assessed at the level of 8e- 7/2013: BNL was able to conduct a readout of the science CCDs meeting all requirements (50ms integration, 9.2Hz rate) for one vendor. Remaining risk is on the LSST custom electronics chain and sensors coming from the second vendor. 7/2014: now that we have ITL sensor in-hand, we need to assess the performances in guide mode. This has not been done yet. 01/2015: this will be tested in the guide sensor test bed 05/2015: guider testbed components have been purchased and testing will start in the June timeframe at BNL 07/2015: guider timing was demonstrated on an ITL sensor using the WGREB at BNL. The serial readout rate was slower than the final due to excessive capacitance on the video line but the sensor was able to handle the 16us parallel shift time. 01/2016: flex cable demsontrated performance at the correct readout rate. 03/2016: Test at BNL with the final flex cable have showed that the 16us parallel shift time can be met using LSST electronics for the second CCD vendor. Since at 16us has been demonstrated for both vendors this risk can be closed 04/2017: e2v sensors are baselined for guide sensors. Parallel shift time is not as much of a concern with these sensors. 11/2017: reacessment of risc with keeping the sensors and potentially redesigning the GREB board as post mitigation solution	Test with sensor and representati ve electronics	2/1/2018	2/1/2018	1	2	2	2	2.3	Insignificant	$30	$150	$200	Cost for respinning of GREB board	0.5	1.0	1.5		0%	1%	$0	$2	$10	0.69	0.00	0.01	0.02
I&T	3.08.04	IT-003	Optical Alignment Methodology	IF SMR-based alignment is not suitably precise, THEN alignment specifications may not be met	Roodman	I&T	1-Jul-16	2	2	2	2	4.7	Insignificant	Anal	Study alignment plans	1) Assess accuracy of SMR-based metrology, including a CAD study to assess lines of sight; 2) Develop alignment method using rotator as optical turn-table with laser collimation 3) Investigate using CCOB ghost image testing as a more precise measurement method		Hold	6/2015: Moved status to holding. Will hold until alignment complete. 11/2013: completed Alignment Review, laying out full plans and tol analysis showing SMR-based alignment meets camera req's 8/2013: completed draft of alignment tolerances, showing they produce optical alignment precision and accuracy that meets I.Q. req's; completed initial line-of-sight study to assess access for SMR-based metrology 6/2013: discussed concept to use the rotator as an optical turntable; re-started work on alignment plan 9/2011: Develop concept for alignment including tolerances.	PSR		8/1/2019	2	2	2	2	4.7	Insignificant	$30	$200	$200		0.5	1.5	1.5		1%	5%	$2	$10	$30	5.15	0.02	0.08	0.08
EXCH	3.06.03	EXCH-011	Filter attach latch	IF the filter latch mechanism does not operate reliably, THEN the subsequent re-design will have a big impact on the entire system, given that we are out of room	Karst	Fab	16-Jun-17	2	2	2	2	4.7	Insignificant	ETU	Filter latch test unit	Run latch prototype testing to demonstrate reliability for all operating scenarios; run life testing to characterize the impact of wear on performance		Working	02/2018 : The Long duration test with particule measurement is planned in 2019. 05/2017 : The latches reliably worked during the stand-alone test of the Auto changer. The long duration test is left to do. 01/2017 : Results expexted in April 2017 11/2016 : The cabling is not finished. Results with the Auto Changer stand alone test will not be available before January 2017. 8/2016 : The cabling of the Auto Changer Prototype is scheduled in September 2016. The test will be done in October 2016. 4/2016 : The fabrication met non-conformance which delay the assembly (1 month). 2/2016 : The Auto Changer Full Scale prototype assembly will start on february 2016, the first test will be performed in April and May 2016. 5/2015: The Complete AutoChanger prototype will be test in march 2016. 4/2013: The filter latches have been tested on the Single filter Test in real configuration with the carousel clamps 4/2010: waiting on personnel to design test unit	EXCH Proto test	9/1/2019	11/1/2017	2	2	1	1	3.3	Insignificant	$30	$30	$200	offset cost	0.0	0.0	0.5		1%	5%	$0	$2	$11	1.75	0.00	0.00	0.03
EXCH	3.06.03	EXCH-014	Carousel clamp	IF Carousel clamp does not function reliably, THEN exchange capability may be severely limited	Karst	Fab	16-Jun-17	2	2	2	2	4.7	Insignificant	ETU	Clamp test bench	Prototype clamp mechanism (incl instrumentation); load test and life test unit to demonstrate reliability		Working	05/2018 : Improvement of parts are in progress 02/2018 : After the tests, improvement need to be applied on the clamps : better friction coefficient on sliding part. In progress 11/2017 : A first test of 1000 cycles has been performed. New tests are expected in the next week in December 17. 09/2017 : The test bench is ready, the test are planned for the next fall 06/2017 : Results expected in September 2017 01/2017 : Results expected in June 2017 08/2016: The Long run test is delayed for end of 2016 02/2016: The end of the long run clamp test is scheduled for August 2016 05/2015: The life test will be achieved in march 2016 10/2013: More than 300 cycles has been performed on the single filter test without any failure of the clamps 12/2012: Single filter test began, individual clamp tests continue to demonstrate reliability and lifetime 4/2010: Test bench complete; clamp proto testing underway; life testing to follow	EXCH Proto test	July 18	11/1/2017	2	2	1	1	3.3	Insignificant	$30	$30	$200	offset cost	0.0	0.0	0.5		1%	5%	$0	$2	$11	1.75	0.00	0.00	0.03
Cmr Rft	3.04.02.03. 03	Crft-009	CCD Guide Sensor Performances	CCD sensors readout technique is novel and issues related to timing, smearing and saturated pixels is not understood.	Herrmann	ETU	5-Jun-15	2	2	2	2	4.7	Insignificant	Study	Study smearing during read-out	Study effect of saturated pixels in a row related to the guide window (done at BNL) Readout mode control scheme development using first Corner Raft (still pending as a mitigation)		Working	9/2011: Preliminary smearing study and readout speed and modes has been conducted (Document-9095). 7/2013: actuall testing of CCD250 in guider readout showed that smearing does not appear to be a problem. 12/2014: guider mode performances are expected to start in January 2015 at Harvard 01/2015: guider testbed equipment has been identified and is being purcahsed at Harvard 04/2015: sensor is under vacuum at Harvard and will be tested in the May/June timeframe. 07/2015: guider timing was demonstrated on an ITL sensor using the WGREB at BNL. The serial readout rate was slower than the final due to excessive capacitance on the video line but the sensor was able to handle the 16us parallel shift time. 04/2017: e2v sensors are baselined for guide sensors. There are less unknow with e2v sensors. No sensors are available to conduct these tests. 10/2017: plan for testing smearing and other guide sensor related readout potential issues will be done on the first corner raft in January/Febriuary 2018 11/2017: reaccess the risk with keeping the sensors and use operational changes as post mitigation resolution		2/1/2018	2/1/2018	1	1	2	2	1.8	Insignificant	$0	$0	$30	mitigation would notinvolve new sensors but rely on operational changes to limit impact on performance	0.5	1.0	1.5		0%	1%	$0	$0	$0	0.03	0.00	0.01	0.02
SE	3.02.02	SE-006	Camera convection	IF camera develops local natural convection cells inside, THEN image quality could be impacted	Nordby	I&T	17-Oct-17	3	1	1	2	4.5	Insignificant	Anal	Camera convection model	Develop convection analysis model to establish cooling requirements and air flow (COIMPLETE); Study convection in camera (COMPLETE); Finalize camera volume purge air flow to reduce risk of convection cells (COMPLETE)		Accepted	10/2017: Complete L1 and L3-Filter region combined convection-conduction-radiation thermal analysis; results show air velocity is adequate to reduce risk of natural convection cells; no Zemax analysis performed; propose closing this risk since no further mitigation is planned 12/2015: L3 analysis indicates that natural convection will not be an issue; still finalizing thermal analysis then to Zemax for optical analysis 7/2015: L1-L2 CFD model complete; working on export to Zemax and L3 analysis; room for adequate L3 cooling is questionable and needs design work 2/2015: L1-L2 interface with purge has been defined for the vendor. Analysis to be performed. 9/2014: purge system heat transfer analysis completed for Cam Body PDR, showing it can remove heat; no work done on integrated CFD analysis of camera; 3/2013: updated heat loads; finalized ICD req's on skin temp; thermal analysis not started yet 9/2011: developed system conceptual design; spec'd heat loads 4/2011: Not started	Camera Body FDR	9/1/2016	8/1/2019	3	1	1	2	4.5	Insignificant	$0	$30	$30		0.0	0.5	0.5		5%	25%	$2	$8	$10	3.75	0.03	0.13	0.13
CCS	3.07.01.02	CCS-005	Communicatio ns latency	If communications response times do not meet requirements THEN camera performance may not meet the specified requirements.	Johnson	I&T	22-May-15	3	1	1	2	4.5	Insignificant	Proto	Communicatio ns testing	Communications latency will be tested in test stands and pathfinder exercises, and will also be measured as part of verifcation and validation.		Working	3/24/2015 The total time budget for CCS overhead during a "visit" has been reduced to 40ms. Since a visit requires many message round-trips this reduces the budget per message to a lower level than has been tested/demonstrated. 5/15/2018 Initial test of communication latency have been tested on test stands at SLAC and BNL and during CCS/OCS/TCS/DM pathfinder exercise. No serious problems have been found. Final testing will be performed during I&T full-camera operations.	I&T		3/1/2020	1	1	1	2	1.5	Insignificant	$0	$0	$30	Accept minor performance hit	0.0	0.0	0.5	Accept minor performance hit	0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Current Assessment: Impact of Risk				Current Assessment: Exposure Level		Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment: Risk Identification					Residual Risk: Post-Mitigation Assessment: Impact of Risk				Residual Risk: Post-Mitigation Assessment: Exposure Level		Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
CB&M	3.06.02.02	CBM-034	Shutter turn-on time	IF the Shutter takes a long time to turn on, THEN it will not meet its 1 sec opening time req, and obs will not meet its cadence req	Nordby	Fab	17-Oct-17	3	1	1	2	4.5	Insignificant	ETU	Shutter drive system test unit	1. Run timed turn-on tests with drive train test unit to assess speed with which controller/motor can turn on, release the brake, find its position, and start an actuation; 2. Test faster open/close times to buy margin for turn-on		Working	5/2017: Stepper control and power schematic is being finalized, which will better inform turn-on plans for prototype 11/2016: Drive train prototype fab complete; testing started, including turn-on time 8/2016: Final controller design provides for immediate motor starting, with no expected bootr-on cycle 11/2015: updated ICD with OCS to provide advance warning of an exposure, which provides an operational way to eliminate the risk; still plan to work through mitigations 5/2015: drive train test unit being detailed 4/2014: updated proto plan includes turn-on tests to resolve this risk early; analysis shows that 0.5 sec opening time is feasible, to accommodate extended turn-on 4/2013: proto work not started due to funding constraints 3/2011: Development on test bed is starting to examine turn on and handoff from brake to motor actuation.	10/17/2017	10/17/2017	12/1/2018	2	1	1	1	2.3	Insignificant	$0	$30	$30	Accept performance	0.0	0.0	0.5		1%	5%	$0	$2	$4	0.75	0.00	0.00	0.03
Cryo	3.06.04.06	Cryo-023	Refrigeration: Mount Top End Cap Plumbing Geometry	If the refrigeration plumbing routing through the mount top end cap creates pooling and accumulation of condensables or oil in the refrigeration system THEN the required temperature, stability or uniformity of the cryoplate / sensors will not be achieved.	langton / schindler	ETU	4-Jun-15	3	1	1	2	4.5	Insignificant	ETU		Fabricate and test prototype system to operate the refrigeration system with simulated top end cap plumbing. Establish and validate cooling meeting requirements for capacity, uniformity and stability Should the risk be realized we can: -Install local heaters to minimize condensate pooling. -Change tube diameters to increase flow velocities to sweep condensables and oil away. -Install a secondary oil return system. -Investigate non-observing use scenarios to minimize dwell at inappropriate orientations.		Working	3/2017: Will be able to perform test with the Pathfinder and in B750. 11/2016: Assumes no funding is added to redo testing of the TMA long line configuration. 9-2016: The geometry of TMA has changed and improved. Therefore to test the new design this would require a new set-up and additional budget. 9-2015; completed runs with no indication of unacceptable levels of oil segestration. Plans and hardware in place to complete oil carry over tests (quantitative oil transport and tolerance measurement) 5-2015: no change in risk exposure. need to impliment entire plumbing system / volume to conclude / retire risk 2-2015: no change in risk exposure at this point. testing to date does not indicate the top end plumbing is root cause of "slow plugging" issue discussed in "camera geometry" risk status, BUT this is not definitive and the complete solution may include a change in this plumbing to increase flow velocities and oil carriage. updated retirement date to CD-3 10/2014: Completed additional runs with top cap plumbing simulated, long runs resulted in adequate performance but we have had plugging issue with partially cooled system start up attempts, still researching and testing to determine root cause, mitigations are being developed (different mix, local heaters where required, etc). updated retirement to CD-3 8-2014: completed intial cool down of camera and have demonstrated short term cooling and stability but this risk will take a careful and multi-point test program to evaluate in detail and complete full risk mitigation. 4-2014: fabricating plumbing lines that duplicate the top end cap (less flex line sections) and the geometry of the camera. Lines will be installed and interconnected and part of testing	CD-4	5/1/2016	3/1/2020	3	1	1	2	4.5	Insignificant	$0	$0	$30	Assumes no funding is added to redo testing of the TMA long line configuration.	0.0	0.0	0.5		5%	25%	$0	$0	$3	0.75	0.00	0.00	0.13
Cryo	3.06.04.06	Cryo-024	Refrigeration: Long Lines Plumbing Geometry- "J"-Traps.	IF the refrigeration long lines plumbing as routed through the elevation and azimuth articulations creates pooling and accumulation of condensables or oil in the refrigeration system THEN the required temperature, stability or uniformity of the cryoplate / sensors will not be achieved.	langton / schindler	ETU	1-Sep-05	3	1	1	2	4.5	Insignificant	ETU	CEH long lines phase 2	install long lines plumbing the simulates the "j-traps" of the elevation and azimuth articulations of the observatory installation, interconnect to subscale test stand. Test and validate ability of refrigeration system to sweep condensables and oil out of the negative flow areas of the refrigeration system. Should the risk be realized we can: -Install local heaters to minimize condensate pooling. -Change tube diameters to increase flow velocities to sweep condensables and oil away. -Investigate non-observing use scenarios to minimize dwell at inappropriate orientations. -Eliminate negative flow areas with redesign of plumbing at articulations		Working	3/2017: See the above risk. 11/2016: Assumes no funding is added to redo testing of the TMA long line configuration. 9-2016: The geometry of TMA has changed and improved. Therefore to test this would require a new set-up and additional budget. 9-2015: recent start of long lines test, insufficient run time accumulated to allow update of risk exposure. 5-2015: completed additonal tests to conclude questions regarding compressor move, currently planning to relocate compressors as requested which given associated risks significantly reduces J trap exposure 2-2015: continue to work to resolve questions and concern regarding compressor relocation LCR. test to date do not indicate any show stopper issues. additionally testing to date does not indicate J-trap issues cannot be resolved with mitigation measures, though eliminating any traps is always the best mitigation. changed retirement date to CD-3. 10-2014; completed designs of elevatin articulation and test equipment for evaluating compressor / system perfomrrance with compressor accelrated as on the TMA. parts going to fab, expect testing to start early 2015. 8-2014: complete intial BCR request and impact assessment to relocate compressors to the TMA, goal to eliminate risk with system reconfiguration in the telescpoce context 4-2014: all flex lines required are procured and ready for install. linterconnect hardware procured. Articulation and Support designs complete, material in hand, detail fabrication and installation-assembly planned for spring summer 2014.	CD-4	5/1/2016	3/1/2020	3	1	1	2	4.5	Insignificant	$0	$0	$30	11/2016: Assumes no funding is added to redo testing of the TMA long line configuration. assumes test program shows a problem and refrig system has additional devt cost	0.0	0.5	0.5		5%	25%	$0	$0	$3	0.75	0.03	0.13	0.13
Cryo	3.06.04.06	Cryo-037	Rubber hose long term reliability	IF the material choice for the hoses is not compatible with the refrigerant long term, THEN maintenance schedule could be impacted.	Callen		20-Sep-16	3	1	1	2	4.5	Insignificant	ETU		Continue ETU studies on refrigeration system long term.		Working	1/2018: Will test two types of hoses in IR2 to determine if one of the hose may be less likely to draw moisture into the refrigerant. 3/2017: Rubber hoses has not been a problem for 10 months when installed on the system. System has not been running continuously. 9/20/2016: Rubber hoses have been tested (approximately 1.5 years), but continued studies will determine if there is a long term issue. This scope should be considered after project refrigeration budgeted activities end.		CD-4	3/1/2020	3	1	1	2	4.5	Insignificant	$0	$0	$30		0.0	0.0	0.5		5%	25%	$0	$0	$3	0.75	0.00	0.00	0.13
Cryo	3.06.04.06	Cryo-046	Telescope interface	If the agreements with the TMA impact the final design, THEN the performance of the system may be impacted as the design decisions are constrained by the interface agreements	Callen		20-Nov-16	3	1	1	2	4.5	Insignificant			Refrigeration pathfinder		Working	11/2016: TMA is constructing the mount and so some of the remaining design decisions are constraned by the completed designs at external interfaces. Plumbing material, line sizes and connections. Line sizes were made as large as it was reasonable, so this should have minimal impact to design changes. Material choice was the most optimum at the time and has been tested. The jumpers and connections are added pressure drops and could have a slight impact to pressure drop and performance of the system. Note, no cost to project as pathfinder was planned to be on operations. System has demonstrated full compliance with the performance specification, so no known design changes are required. Improvements are being suggested by the team for longer reliability and increased capacity margin			7/1/2017	3	1	1	2	4.5	Insignificant	$0	$0	$30		0.0		0.5		5%	25%	$0	$0	$3	0.75	0.00	0.00	0.13
CCD		CCD-002	CCD damage during assembly	IF some CCDs are damaged during assembly THEN we may need to order additional sensors	Takacs	Fab	Oct 26 2015	3	1	2	1	4.5	Insignificant	Anal	CCD Handling	1) Establish robust processes for handling and installing CCDs to ensure these high dollar devices are not damaged 2) Keep some spare sensors in the plan (current spare count is 12 sensors on reserve with non-conformance and 30 spare science grade planned to reduce residual risks)		Working	10/2017: one e2v sensor damaged. Award of SLIN-003 will add 3 rafts worse of spares. 6/19/17: 3 damaged sensors rewirebonded at e2v. 2 returned and retested to have same EO as before damage & repair. 3rd due back soon. 2/15/17 Wire bond damage on sensors from secondary vendor observed while handling at TS-2 in MF-07. Procedural study to eliminate damage underway. Number of sensors affected small. All probably recoverable. 10/26/15 The protective covers and handling fixtures work quite well as demonstrated during TS1-3 trials as well as during mock installations on TS4. 10/10/14: Careful consideration being given to all fixtures that touch sensors, and handling procedures.	End of SR Production	4QFY18	9/1/2017	3	1	2	1	4.5	Insignificant	$0	$0	$30	10/2017: SLIN-003 award project 30 spares, so no cost impact if a sensor is lost 11/2016: heterogeneous baseline still has 49 spares. No cost impact. 10/2016: current homogeneous baseline has many spare Since the baseline plan has a low number of spares, damage to one or more CCDs will require the procurement of additional sensors	0.5	0.5	1.5	half a month to retrofit the damage sensor	5%	25%	$0	$0	$3	0.75	0.03	0.13	0.38
Cryo	3.06.04.06	Cryo-078	Cold Refrigeration System Verification	IF the dummy load on the cold plate failed to provide adequate heating, THEN the system will get too cold and unable to test to the specification				3	1	2	1	4.5	Insignificant			1) We can cycle the cold system on and off 2) change compressor to smaller displacement compressor		Working	Rewire heater and add power supplies and additional feedthroughs				2	1	1	1	2.3	Insignificant	$0	$30	$30		0.0	0.5	0.5		1%	5%	$0	$2	$4	0.75	0.01	0.03	0.03

LSST Camera Risk Registry

Risk Identification							Current Assessment							Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
									Impact of Risk			Exposure Level											Impact of Risk			Exposure Level																		
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Cam	3.01	CAM-018	IN2P3 Cash Contribution	IF IN2P3 cash contribution is not received in time, THEN the project may have to draw on expected available contingency	Riot	Mng	20-Nov-15	2	3	1	1	4.3	Insignificant	Study	iCRADA	1) Capture opportunity in EAC (DONE) 2) Secure CRADA signaturess (DONE) 3) Work with LSSTCorp to setup the fund transfer (IN2P3 to LSSTCorp to SLAC) (DONE)		Working	10/2017: $200K sent by IN2P3 02/2017: $600K recieved at LSSTC against the $2M. 01/2017: CRADA has been signed and first installment expected to be received at LSSTC. 11/2016: IN2P3 has signed the CRADA. Work remain to understand what happens next and when funds are expected to be transferred 10/2016: IN2P3 iCRADA being reviewed in France. Based on timing of the contribution and current changes in the sensor baseline plan as apporved by BCR-035 (level 1 BCR), this risk is converted to an opportunity or about $2M. 8/2016: IN2P3 cash contribution is less than CD-2, but we are expecting $2M, so this cash risk remains. 11/2015. IN2P3 cash contribution shortfall realized. Baseline budget adjusted together with changing sensor vendor to the lowest cost. 7/15: MOU signed by IN2P3, but not by DOE and SLAC. The current baseline budget had the significantly more expensive sensor. It is possible that this money isn't needed or we could decide to have some rafts from the less expensive vendor.. Decision is to wait until the downselect to execute a BCR, 12/14: MOU completed and signed by IN2P3, $3Meuro shortfall. Additional funding may not be required, as this is dependent on sensor vendor selection. 4/9/14: Agreement being finalized for CD-2 11/2013: Visit with IN2P3 to finalize MOU - could have a shortfall of $1M for sensors 5/2013: Sensor procurement funds have solidified 10/2013: IN2P3 has been solidifying this funding	CD-4	6/1/2020	1/1/2018	2	3	1	1	4.3	Insignificant	$0	$600	$1,200	Does not include exchange rate. iCRADA to be signed lists $2M. Timing of fund availability not defined and none of te funding could come on time. Assumes half of remaining balance it is not useable.	0.0	0.0	0.0		1%	5%	$6	$30	$110	18.00	0.00	0.00	0.00
Cam	3.01	CAM-017	IN2P3 Exchange System Fabrication Funding	IF IN2P3 exchange system hardware is not adequately funded to support their planned participation, THEN management reserve or descope will be needed to cover the shortfall	Riot	Mng	15-Jul-15	2	3	1	1	4.3	Insignificant	Study	Obtain Commit.	1) Identify and obtain commitments from all Laboratories, and documented in CRADA (DONE with iCRADA)		Working	11/2013: Visited IN2P3 labs and attended PDR for the exchange system. Prototype hardware funding is available. 9/2011: Fabrication costs are within the Lab's budget.	CD-4	6/1/2020	1/1/2018	2	3	1	1	4.3	Insignificant	$150	$300	$1,500	WAG on cost of making the filter exchange. Residual probability is low as of 02/2018 given that most of the parts are in hand. IN2P3 shortfall appears to be in the $150K.	0.0	0.0	0.5		1%	5%	$3	$15	$91	14.25	0.00	0.00	0.03
Cam	3.01	CAM-023	ComCam Scope	IF ComCam scope is revised due to current design maturity, THEN the cost may increase	Riot	Design	15-Jul-15	2	3	1	1	4.3	Insignificant	Study	ComCam Scope Risk & Opportunity	1 - Normal engineering work 2 - Use ETU1 or ETU2 as the raft for additonal flexibility (or to prevent issues with damage of one ETU)		Working	2/2018: ComCam EPR was completed successfully 04/2017: ComCam TDR was completed. Still some interface issues to update 03/2017: ComCam replan was completed as part of BCR-046. probability of scope change reduced 10/2016: ComCam planning package update to detail the scope of work is expected to be completed in october 2016 7/2015: lowered probability - scope is stable 12/2014: ComCam Design Document completed with LSST and LSSTCam 10/2014: Updated Residual Risk data, discussion held with Telescope and LSST Project. The camera scope is clear, but the telescope has to work out the basic design and how it integrates with their telescope. 10/2013: original entry	CD-4	2/1/2019	6/1/2017	2	3	1	1	4.3	Insignificant	-$500	$250	$500	5/2018: Remaning ComCam cost to go is only $500K (ComCam hardware almost complete). The project has 2 ETUs to populate ComCam (as a mitigation) ComCam need could be eliminated or reduced by LSST, especially if the Camera is ahead and the Telescope is behind schedule	0.0	0.0	0.5		1%	5%	$3	$13	$41	5.00	0.00	0.00	0.03
Sci Rft	3.04.01.03	Srft-061	Sensor Performance Surprises	IF there are aspects of sensor performance that impact science, despite passing our specs, THEN LSST survey performance will be compromised	Stubbs	Design	5-Jun-15	2	1	1	4	4.3	Insignificant	Study	Lab measurements	Coordinated testing plan at the sensor and raft level will mitigate this		Working	5/15/18 DESC Sensor Anomalies Working Group (SAWG), PST, and I&T scientists have access to test data and are conducting impact studies on noise, tree rings, brighter-fatter, CTI, tearing. No new "surprises" 10/18/16 UC Santa Cruz has obtained engineering-grade sensors which will be parceled out to DESC labs for detailed examination of performance issues not covered in the specification 10/10/14: Detailed characterization of first-article sensors. 4/8/2014: Ongoing	CD-4	7/1/2018	9/1/2018	2	1	1	1	2.3	Insignificant	$0	$20	$30		0.0	0.4	0.5		1%	5%	$0	$1	$3	0.55	0.00	0.02	0.03
Opt	3.05.03	Opt-004	L1-L2 strut stiffness	IF L1-L2 strut actual stiffness is lower than needed, THEN added deflection would impact image quality performance	Wolfe	Fab	15-Jan-16	2	2	1	2	4.0	Insignificant	ETU	L1-L2 strut prototype	Prototype strut to verify performance of real hardware. Provide LSST design to vendors during the procurement design phase.		Working	7/2014: Vendor is under contract to meet L1-L2 opto-mechanical specs under fixed-price design-build contract; has accepted specs for alignment tolerances and settling time; likely that stiffness problems would be identified at vendor during integration and testing resulting in delivery schedule delay while new struts designed & fabricated 2/2013: Delta CoDR design improved the struts mechanism using a cross-blade design. This new design reduces hysteresis but the strut stiffness risk is still present.	L1-L2 FDR		8/1/2018	1	2	3	2	2.7	Insignificant	$30	$150	$200	Make new struts; would likely go back to design-build vendor who has FEA model of struts; Even though it is fixed price contract, there could be cost risk for accelerating response or potential for unanticipated change order	1.5	1.5	3.0	Delay beyond the current float of approx 120 days	0%	1%	$0	$2	$10	0.69	0.00	0.02	0.03
ELX	3.08.03	ELX-003	AC Power Control	If too many large loads require AC power control and monitoring, may exceed space or power constraints.	Haller	Design	7-May-18	2	2	2	1	4.0	Insignificant	Anal	AC Load Definition	Finalize list of loads and requirements for each load		Working	5/7/18: gettign close but not all components are installed yet 8/6/16: Power requirements are now well understood. The total power requirement will not be an issue, and the cooling should be OK, but this analysis is not complete. The space issues are still being worked on. There will ultimately be a solution. 11/14/2013: Load list getting, no surprises to date Cryostat and UT designs are maturing. 5/26/15: Have updated power load lists with preliminary design for breaker panel and switching/monitoring chassis	Auxiliary Electronics FDR	6/1/2018	9/1/2018	1	2	2	1	2.0	Insignificant	$10	$50	$75		0.0	1.0	1.5		0%	1%	$0	$1	$3	0.24	0.00	0.01	0.02
CB&M	3.06.02.02	CBM-044	Shutter blade layup tolerances	IF the shutter blades cannot be manufactured to the flatness and position tolerances then they may encroach on neighboring blades	Nordby	Fab	12-May-17	2	2	2	1	4.0	Insignificant	ETU	Shutter blade prototype	1. Perform manufacturing study prototype to demonstrate ability to meet needed tolerances (COMPLETE)		Accepted	11/2016: Blade protos complete; final flatness is within increased spec value and blade re-design is more manufacturable 8/2016: Moved filter 3 mm to provide more room to handle larger blade flatness tols and more clearance between blades; 2nd round of blade prototypes is being fabricated now 3/2016: Blade fab underway; initial manufac testing shows flatness is difficult but appears to be achieved; waiting on final report 11/2015: Modified design to improve manufacturability; blade prototypes in production (ECD: Feb-2016) 5/2015: Prototype tolerances are tight for manfucaturers, so production costs could be high 3/2015: proto design complete, w/ good method to produce and check relatively tight tolerances with assy jig to reduce likelihood of out-of-tol parts; fab just starting; 5/2014: updated development plan to incude blade prototyping, to show fab method can produce req'd tols Started costing and design prototypes	9/16/2016	9/16/2016	11/1/2017	2	2	2	1	4.0	Insignificant	$30	$30	$200	Procure additional blades and pick the best. Number of blade sets has been reduced from 3 to 2 to save money on the 11/2016 EAC, so additional funds may be needed if final blade build produce blades that are not flat enough	0.5	0.5	1.5		1%	5%	$0	$2	$11	1.75	0.01	0.03	0.08

LSST Camera Risk Registry

Risk Identification							Current Assessment: Risk Identification							Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																				
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
CB&M	3.06.02.02	CBM-037	Shutter blade clearances	IF the clearances between the shutter blades, L3, and filters are too small, THEN there could be scraping causing particulate generation or jamming of the mechanism	Nordby	Fab	17-Oct-17	2	2	2	1	4	Insignificant	Proto	Shutter prototype	1. Fully define all subsystem stayclear envelopes and interfaces (COMPLETE) 2. Set blade tols and dynamic deflection specs, based on worst-case dynamic clearances (COMPLETE) 3. Measure as-built tolerances of prototype shutter blades to show they can meet req'd tols (COMPLETE) 4. Measure position of prototype components to verify compliance with stayclears		Working	5/2017: FDR design includes all changes for 3 mm move; tol analysis shows we have adequate room 11/2016: Proto blade flatness is within new stayclear zone; update shutter stayclear and clear apertures defined for filter 3 mm move and IDD is almost ready for release. 8/2016: Modified blade layout for improved manufac tols. Moved filter 3 mm to give more room for clearances between parts in the shutter 3/2016: Blade prototype being fab'd now--ECD: May 2016; 11/2015: modified blade design to simplify and improve manufacturability, with expectation that req'd tolerances can be met with the updated design; blade proto's in fab now (ECD: Feb-2016) 5/2015: Proto blade flatness comes at a cost premium; if this carries into production then budget will be impacted 3/2015: proto design complete, w/ good method to produce and check relatively tight tolerances with assy jig to reduce likelihood of out-of-tol parts; fab just starting; 5/2014: updated development plan to incude blade prototyping, to show fab method can produce req'd tols 2/2014: updated prelim design carries adequate margin to all optical elements; analysis shows dynamic deflections fit within allocated envelope; 8/2013: changed to 2-blade design to increase clearance; stiffened blades, brackets, and carriage interfaces 4/2013: investigating 2-blade shutter to increase clearances 3/27/13: Stay clear envelopes in work, need checking.	8/1/2018	8/1/2018	8/1/2018	2	2	1	1	3.3	Insignificant	$30	$200	$200	Go to higher-modulus fibers and stiffer bracket matl's, or higher rejection and re-work rate during production if flatness cannot be achieved	0.0	0.5	0.5		1%	5%	$2	$10	$30	5.15	0.01	0.03	0.03
Opt	3.05.04	Opt-036	Disassembly/Reassembly of L3 on summit	IF the L3 Assembly has a vacuum leak (bad seal), THEN the L3 Assembly will need to be disassemlbed and repaired.	Wolfe	Op	4-Dec-15	2	2	2	1	4.0	Insignificant	Study	Design and Testing	The L3 Assembly is designed to meet lifetime requirements and has no required replacement seals or components . Vacuum design utilizes two seals, a main and guard seal. This provides a level of protection. The assembly could be shipped offsite and returned in less than 3 months.		Working	12/2015: Vendor is working towards final design.			3/1/2019	2	2	2	1	4.0	Insignificant	$30	$50	$200	Costs based on shipping offsite and repair once during the lifetime.	0.5	1.0	1.5		1%	5%	$1	$3	$13	2.15	0.01	0.05	0.08
I&T	3.08.01	IT-038	Camera Assembly Stand Drive Failure	IF the Camera Integration Stand has any type of drive failure during the Camera assembly critical path chain of event, THEN there will be a corresponding delay in delivery of the camera.	Bond	I&T	31-Jan-18	2	2	2	1	4.0	Insignificant	Study	Alternative Drive Options	1: Additional efforts are being made for designing for reliability (i.e. designed for increased MTBF). 2: All of the drive motors are being designed such that additional access is available for "manual" intervention.		Working	1/31/2018 - Initial Entry		5/5/2020	5/5/2020	1	2	2	1	2.0	Insignificant	$30	$50	$200	Cost of replacing motors/electronics and associated techn work	0.5	1.0	1.5	Down time associated with event	0%	1%	$0	$1	$5	0.36	0.00	0.01	0.02
I&T	3.08.01	IT-039	Camera Assembly Stand Delivery Delays	IF the Camera Integration Stand is commissioned and verified late, THEN there will be a corresponding delay in delivery of the camera.	Bond	I&T	31-Jan-18	2	2	2	1	4.0	Insignificant	Study	CIS Accelerated Schedule	1: Additional efforts are being made to accelerate the design and development phase and to increase the "float" to delivery to the critical path (additional staff are being mobilized and dedicated to the development of this system). 2: Some of the assembly and test preparations can occur while awaiting fabrication of the main structure. 3: Assembly and testing will have additional staff applied in order to reduce the total duration for these activities.		Working	1/31/2018 - Initial Entry		9/1/2018	9/1/2016	1	2	2	1	2.0	Insignificant	$30	$50	$200		0.5	1.0	1.5		0%	1%	$0	$1	$5	0.36	0.00	0.01	0.02
Cryo	3.06.04.06	Cryo-050	Leaks in the refrigeration line	IF the refrigeration system leaks, THEN it will impact the schedule	Callen			2	2	2	1	4.0	Insignificant			1) Run the system in IR2 to qualify all components and system for leaks for IR2 2) Fix leak in the pathfinder system before install the system for TMA		Working	3/2018: Use pathfinder to find leak for the TMA system 4/2017: The leak will be known during preparation for IR2 in September 2017.			9/4/2017	2	2	2	1	4.0	Insignificant	$30	$50	$200		0.5	1.0	1.5		1%	5%	$1	$3	$13	2.15	0.01	0.05	0.08
Sci Rft	3.03.02	Srft-017	Thermal impedance variations	IF the thermal impedance on the CCD is not uniform on all CCD THEN CCD temperature may not be controlled within requirement and calibration will not work (QE, Gain, crosstalk)	Wahl	Design	5-Jun-15	2	1	1	3	3.7	Insignificant	Study		Build test stand with RSA in dewar using prototype thermal straps and prototype RSA to quantify thermal impedance, and variation as a function of thermal cycling.		Working	5/15/18 The observed scatter in CCD temperature in RTM12 during a 1.5-hour imaging run in TS8 was 0.87 degrees C, indicating satisfactory thermal impedance match. For this reason, the probability score is now reduced to 2 (unlikely). 9/11/17 Detailed modeling and thermal tests are being performed to best characterize the SRTMs thermal performance (results expected in November 2017). 10/18/16 TS8 will be commissioned using ETU-1 in late November '16, where the RSA/RTM will be characterized including thermal impedance. 12/10/14: Mechanical test stand and LabView control software has been completed. Currently working on vacuum leak as last problem before tests can begin (KV). 10/14/14: Mechanical test stand online, initial characterization tests have started. 4/9/2014: Plan to procure TS3 dewar for analysis of engineering sensors on prototype RSA	Completion of Thermal Modeling & Tests	10/15/2017	8/1/2018	1	1	1	1	1.2	Insignificant	$0	$10	$30		0.0	0.5	0.5		0%	1%	$0	$0	$1	0.06	0.00	0.01	0.01
Sci Rft	3.04.01.02	Srft-053	Temporal stability of sensor placement	IF sensor placement changes over time THEN focal plane image height requirement will not be met and image quality will be degraded	Takacs	I&T	5-Jun-15	1	4	3	2	3.7	Insignificant	Study		Run thermal cycle tests on several sensors mounted in a real raft. Plan to fabricate TS7 dewar for mechanical design qualification testing. Also will evaluate both CE7 and CeSIC RSA materials including thermal cycling.		Accepted	1/17/17 ETU1, ETU2 & RTM1 were measured at TS5 and the Sensor flatness has remained unchanged after returning to room temperature. A convex shape is observed on the CCD surface when cooled but it consistantly returns to a flat condition after thermal cycling. ETU1, ETU2 & RTM1 represents 27 CCDs. 10/18/16 Warm/Cold CCD metrology has begun at TS5 using the RSA for ETU#1 and early results are quite good (Sensors remain flat after thermal cycling). Additional testing will be performed prior to RTM production using the RSA for ETU#2. 6/2015: Suggest retiring risk if this was demonstrated by thermal testing. 4/8/2014: Perform mechanical qualification test (unfunded) 5/2013: height flatness requirements have been relaxed.	TS5 Commissioning Complete	12/1/2016	9/1/2018	1	4	3	2	3.7	Insignificant	$0	$1,500	$10,000	Design qualification program will qualify RSA material to ensure height deformation over lifetime of thermal cycles is compliant.	0.0	2.0	3.0		0%	1%	$0	$15	$222	13.33	0.00	0.02	0.03
Opt	3.05.03	Opt-029	L1 Refractive Index Inhomogeneity	IF the L1 or L2 Refractive Index Inhomogeneity variation is larger than estimated, THEN additional IQ allocation will be required from the Project.	Wolfe	Fab	15-May-18	2	1	2	2	3.7	Insignificant	Anal	Vendor Fabrication Plans	Refractive Index Inhomogeneity will be corrected during Lens fabrication for spatial frequencies greater than 28mm. If correction is unsuccessful, additional IQ allocation will be provided by the Project.		Working	5/2018: both L1 and L2 final TWF results were accepted individually. There is a very small possibility that inhomogeneity will show up in integrated testing. 10/2017: L1 TWE testing showed inhomogeneity is not an issue. Final figuring is in process now with completion by Dec 2017. Currently working with L1-L2 Assembly vendor	FDR		2/1/2018	2	1	2	2	3.7	Insignificant	$0	$0	$30		0.5	0.5	1.5		1%	5%	$0	$0	$1	0.15	0.01	0.03	0.08

LSST Camera Risk Registry

SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Current Assessment: Status Date	Prob ability	Impact of Risk: Cost	Schd	Perf	Exposure Level: Score	Current Exposure	Mitigation Plan: Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Target Retirement: Milestone	Date	Date Will Occur	Residual Risk: Post-Mitigation Assessment: Prob ability	Impact of Risk: Cost	Schd	Perf	Exposure Level: Score	Residual Exposure	Post-Mitigation Cost (k$): Min	Expect	Max	Comments	Post-Mitigation Delay (mo.): Min	Expect	Max	Comments
Sci Rft	3.04.01.04	Srft-063	ITL Reliability - lifetime	ITL sensors have not been subjected to lifetime tests. Thermal cycling could potentially degrade and/or damage sensor	Wahl	Design	5-Jun-15	2	1	2	2	3.7	Insignificant	Study	Lab measurements	Perform thermal cycling of ITL sensor		Working	5/15/18 As of May 2018, a total of 5 ITL Rafts have been constructed with ITL Sensors (ETU1, ETU2, RTM1, RTM8 & RTM10). Each of those Rafts have received cold EO testing at TS7 at BNL and some of them more than once. ETU1 & ETU2 were both tested at SLAC as well (more than once). No apparent degradation has been observed thus far but more statistics is needed before recommending closure of this Risk. 2/14/17 Although the RSAs for ETU1, ETU2 & RTM1 were measured after a few thermal cycles, more testing is needed to provide meaningful statistics. Additional thermal cycling tests will be performed in the future but will require TS7 Cryostat time, which is will not be available in the foreseeable future. 1/17/17 ETU1, ETU2 & RTM1 were measured at TS5 and the Sensor flatness has remained unchanged after returning to room temperature. A convex shape is observed on the CCD surface when cooled but it consistantly returns to a flat condition after thermal cycling. ETU1, ETU2 & RTM1 represents 27 CCDs. 10/18/16 Multiple thermal cycles of 9 sensors on raft baseplate being performed over this next month. Results will become available in December, which will likely facilitate closure of this Risk.	After performinng EO testing of RTM1, RTM8 & RTM10 at SLAC	8/30/2018	3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$0		0.0	0.0	0.5	
Cam	3.01	CAM-037	Lack of L3 spares	If L3 is damaged during construction or integration THEN the project would fail to meet KPP's and CD-4 milestone	Riot	Mng	15-Jul-15	1	3	5	1	3.5	Insignificant	Study	Process Controls	Plan all processes involving optical elements to minimize damage.		Working	10/2016: L3 is under fabrication at TSESO.	CD-4	6/1/2020	10/1/2016	1	3	5	1	3.5	Insignificant	$200	$400	$600	Cost of remaking L3 per current contract is $400K	6.0	9.0	12.0	
I&T	3.08.03	IT-025	RAFT storage	IF RAFT delivery maintains schedule but other subsystems cause delay to RAFT integration THEN I&T will have insufficient storage containers to hold excess RAFTs	Reil	I&T	14/5/2018	3	1	1	1	3.5	Insignificant	Study	RAFT storage need awareness	1) plan for up to 9 shipping container on storage in IR2 and 3 on short term storage at BNL (See BCR-040) 2) Additional storage space is being established wih approved funding identified in bcr-xxx.		Working	5/2018 - Additional space is being established with funding approved in BCR-xxx. 10/2016 Initial Entry.	6/1/2018	6/1/2018	11/1/2017	2	1	1	1	2.3	Insignificant	$0	$24	$80	up to 10 more shipping container would be needed at $8K a piece. Nominally 3 more would be needed.	0.0	0.0	0.5	
Opt	3.05	Opt-042	Personnel Availability to assembly	IF sufficient trained personnel are unavailable over a 3 year period to assemble Filters in the OAB, THEN schedule and cost impacts will be incurred.	Wolfe	Fab	17-Feb-16	3	1	1	1	3.5	Insignificant	Study	Management	Plan to use personnel from the OAB to complete assemblies.		Working	2:2016: Have agreements with NIF management to utilize personnel from the OAB		6/1/2019	9/1/2018	2	1	1	1	2.3	Insignificant	$0		$30		0.0		0.5	
Cam	3.01	CAM-038	L1-L2 Delivery	If the L1-L2 delivery is late by 9 months to their baseline date, THEN the camera integration and test will be late by about 2 months	Riot	Procure	15-Jul-15	3	1	1	1	3.5	Insignificant	Study	L1-L2 Delivery	Maintain schedule float for unplanned events. Reduce testing from 6 to 4 months.		Working	2/2018: Schedulke float is 70 days 10/2017: Schedule float is 192 days 10/2014: Entry. Schedule float ~136 days	CD-4	1/1/2019	1/1/2019	3	1	1	1	3.5	Insignificant	$0	$0	$30	no standing army cost	0.0	0.0	0.5	
SE	3.02.02	SE-022	SLAC--Base Facility network connectivity	IF interface req's and plans for SLAC-Base facility are not agreed on and scoped, THEN public or image data network connectivitiy may not provide the bandwidth, latency, and quality of service needed for remote operations of the camera	Johnson	Design	8-Jan-18	2	2	1	1	3.3	Insignificant	Study	Work out ICD requirements	Send T&S and DM teams camera needs for base facility and network connectivity; Work with Obs SE to work through ICD agreements, including initiating new ICD's to capture base facility and long-haul network needs		Accepted	1/2018: LSE-309 describes needs and is being implemented; risk reduced since DM is in process to deliver network connectivity as needed; mitigation work is done and all that is left is to test CCS and DAQ systems from the base facility during integration 04/2016: There were some sessions at the JTM in Feb-16 targetted at reducing this risk. The camera workshop on June 13-14 has some sessions planned ot resolve some of these items. 8/26/2015 Based on discussions with Lambert the US part of the network will be defined in 2016 and the Camera team will be involved in setting requirements for connectivity to ESNET. 7/7/2015 LCR-385 generated to drive corrections to LSE-78 5/26/2015 Added to the topic list for the August LSST Community Workshop 4/27/2015: T&S has agreeed to be responsible for the base infrastructure. 2/2015: the camera has provided the needs. Block diagram has incorporated some of the needs. 7/2014: no progress; not even known who is responsible for addressing this; 9/2013: Sent camera use cases and req's to T&S and DM for comment--no response yet		7/1/2019	7/1/2019	2	2	1	1	3.3	Insignificant	$30	$50	$200		0.0	0.5	0.5	
Cam	3.01	CAM-013	IN2P3 CCS Labor Funding	IF IN2P3 labor for CCS is not adequately funded to support their planned participation, THEN management reserve or descope will be needed to cover the shortfall	Riot	Mng	15-Jul-15	2	2	1	1	3.3	Insignificant	Study	Obtain Commit.	Identify and obtain commitments from all Laboratories for labor, and documented in MOU. Draw on DOE funding to support labor needs.		Working	04/2017: BCR 49 provides more funding to support travel for CCS IN2P3. Risk is partially realized. Risk of further issues increased. 3/2014: APC has hired a new software person. SLAC provided labor (Bernard) to cover shortfall. 11/2013: Visited APC, they have still not hired additional staff for CCS 5/2013: 1 new FTE is needed to replace retiree 9/2011: All required staff is identified and working.	CD-4	2/1/2015	1/1/2018	2	2	1	1	3.3	Insignificant	$30	$200	$200	Nominal guess estimate for additonal labor needed to cover effort planned at IN2P3	0.0	0.0	0.5	
SE	3.02.02	SE-007	Back end cabling	Accommodation for cabling to the feedthrough flange could require a re-design of the back end of the cryostat	Van Berg	Design	28-Mar-11	2	2	1	1	3.3	Insignificant	Study	Back end design	Agree on cabling scheme, routing plan, and integration sequence		Accepted	3/2011: Feedthrough and flange concept complete; layout shows we have adequate room for routing cables	CD-2 Review		4/1/2017	2	2	1	1	3.3	Insignificant	$30	$150	$200		0.0	0.5	0.5	
SE	3.02.02	SE-026	Camera Thermal Design	If the heat-leak between the cryo-system and cold-system is larger than anticipated THEN the cryo-system may not have sufficient margin	Nordby	Design	28-Nov-17	2	2	1	1	3.3	Insignificant	Anal	Refine understanding of camera thermal design	1. Perform detailed thermal analysis (COMPLETE) 2. Re-visit and account for all heat leaks (COMPLETE) 3. Add polished nickel-plated shroud between REB and REC (COMPLETE) 4. Raise the focal plane temperature by 5 degrees (-95) if needed 5. Increase thermal gradient across focal plane to reduce trim heating		Accepted	5/26/2015: New risk added due to the recent doubling of the science raft power budget. This increased the radiation heat leak to the cryosystem and reduced its thermal performance margin. Note, extensive analysis has been done to itemize the heat leak and thermal results, but the radiation heat transfer and small heat conductionpaths could have been missed. It will be late in the process (at camera I&T) before we can verify the heat leaks. 11/2015: ITL readout speed issues with the flex cable show no impact on the thermal budget. However, cryo-system margin is still extremely tight. No change in assessment. 9/2016: cold refrigerator may not be able to maintain the -40C requirement. While this does not impact the electronics, it may increase the heat leak. Schedule impact as been increased based on current state of the refrigeration sub-system. 1/2017: CTM presentation of intermediate results of the Cryostat thermal budget held on 1/11/2017. Update and completion of that analysis targeted for end of January. 2/2017: Completed integrated thermal analysis; final cryo and cold system heat loads appear to be feasible per refrig proto testing 6/2017: RTM delivery shows that this risk is still present and high; 10/2017: Change ops baseline to low-power mode; prelim test data indicates that cold-to-cryo heat leak is not an issue; cryo refrig system testing shows margin to the earlier higher heat load values 11/2017: Early RTM testing showing total power draw and heat leak is less than planned for, further improving margin on refrig design; refrig final design proto testing shows improved performance. Recommend moving to accepted.	Refrigeratio n FDR	12/1/2017	9/1/2018	2	2	1	1	3.3	Insignificant	$30	$100	$200	May require additional verification testing to characterize RTM heat leak or refrig performance	0.0	0.5	0.5	no schedule. Performance degradation will result
SE	3.02.02	SE-005	Camera integration access	IF access to camera components in the Utility Trunk is not as good as CAD models suggest, THEN maintenance and up-time req's would be missed	Nordby	I&T	17-Oct-17	2	2	1	1	3.3	Insignificant	Proto	Full-scale camera mock-up	1. Develop integrated CAD model with plausible integration and servicing concepts (COMPLETE); 2. Develop rational cable and ducting routing (COMPLETE); 3. Design and fab plywood mock-up and use for routing cables, checking access, and swinging wrenches (COMPLETE)		Accepted	11/2017: UT mock-up in use and FDR complete; risk reduced to residual level that can only be addressed during I&T; propose marking this as accepted 10/2017: Mock-up is complete and being used; final design is largely complete with all access and interface issues addressed; expect to continue to use mock-up to resolve issues as they arise 7/2017: UT PDR was successful and a full mockup is in progress. Probability is reduced 2/2017: UT design is still not converging, and access for installation and cabling has not yet been resolved 3/2016: reduced performance impact 2/2016: per Martin's input $300K is the cost to recover from a space problem in the utility trunk.. $50K to 100K is the cost (mostly technician time cost) to build a plywoood mockup. 12/2015: Hired Derek Chow to lead U.T. and electronics packaging 7/2015: Mock-up is started, but access in UT looks very difficult, with more components still to be designed; need dedicated person working this issue 3/2013: mock-up still not started; waiting on UT re-design and one more round of CAD model review 4/2011: Planned for prelim design phase		1/1/2018	2/1/2019	2	2	1	1	3.3	Insignificant	$30	$50	$200		0.0	0.5	0.5	

Residual Probability: Min	Max	Contingent Cost (k$): Min prob* exp cost	Max prob* exp cost	std	Mean	Contingent Delay (mo.): Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
0%	1%	$0	$0	$0	0.00	0.00	0.00	0.01
0%	1%	$0	$4	$29	2.00	0.00	0.09	0.12
1%	5%	$0	$1	$6	0.88	0.00	0.00	0.03
1%	5%	$0	$0	$1	0.15	0.00	0.00	0.03
5%	25%	$0	$0	$3	0.75	0.00	0.00	0.13
1%	5%	$1	$3	$13	2.15	0.01	0.03	0.03
1%	5%	$2	$10	$30	5.15	0.00	0.00	0.03
1%	5%	$2	$8	$24	4.15	0.01	0.03	0.03
1%	5%	$1	$5	$19	3.15	0.01	0.03	0.03
1%	5%	$1	$3	$13	2.15	0.01	0.03	0.03

LSST Camera Risk Registry

SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Current Assessment: Status Date	Prob ability	Impact of Risk: Cost	Schd	Perf	Exposure Level: Score	Current Exposure	Mitigation Plan: Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Target Retirement: Milestone	Date	Date Will Occur	Residual Risk: Post-Mitigation Assessment: Prob ability	Impact of Risk: Cost	Schd	Perf	Exposure Level: Score	Residual Exposure	Post-Mitigation Cost (k$): Min	Expect	Max	Comments	Post-Mitigation Delay (mo.): Min	Expect	Max	Comments	Residual Probability: Min	Max	Contingent Cost (k$): Min prob* exp cost	Max prob* exp cost	std	Mean	Contingent Delay (mo.): Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
SE	3.02.02	SE-021	Stayclear incursion around shutter	IF the Shtr, Auto Chgr, L3, or Filter component design violate their stayclear boundaries, THEN other subsystem components may need to be re-designed to fit within a reduced volume	Nordby	I&T	28-Nov-17	2	2	1	1	3.3	Insignificant	Study	Clearly define stayclears and clearances	Define simplified stayclears to allow for lower-risk evaluation of component fit (COMPLETE); Establish target clearances and fits between stayclears to provide margin and integration and operational clearances (COMPLETE); Assess component fits within stayclears as part of on-going status evaluation of subsystems		Accepted	3/2016: Shutter elec volume and prelim purge ducting defined; details still in-process, but no expected impact on subsystem stayclear volume definitions 12/2015: Identified shutter need for additional volume for control elec, and purge system needs for routing tubes for L3 purge manifolds; still working resolution 7/2015: Identified need for additional volume for L3 purge inlet lines and for shutter HCU/PLC/Elec volume; still working on resolving details of auto chgr purge lines and cable routing 3/2015: nearly complete in releasing all IDDs; 7/2014: completed all IDD's and stayclear assembly models/dwg's; 4/2014: IDD model assembly complete; finishing final evaluation of clearances to allow closure 8/2013: Changed to 2-blade shutter increased clearance margins; all interface models complete, all IDD drawings being drafted 4/2013: updated stayclear models and evaluation of component clearances are nearly complete; target clearance values have been established; updated IDD drawings have not yet been started 6/2016: A change request is in process to add space by moving the filters away from L3 by 3mm in LCR-646. If approved this will help mitigate the risk. 9/2016: LCR-646 was approved and flowed down to various art of the camera. Probability was decreased. 2/14/2017: Completed re-work of shutter and shutter elec; nearly complete with all ducting and cable routing; stayclears have been preserved; 11/2017: Completed all actionable mitigations, and risk reduced to residual level that can only be addressed during	Camera Body FDR	9/1/2016	10/1/2018	2	2	1	1	3.3	Insignificant	$30	$100	$200		0.0	0.5	0.5		1%	5%	$1	$5	$19	3.15	0.01	0.03	0.03
I&T	3.08.03	IT-024	RAFT integration design	IF the planned integration system proves unsuccessful THEN a parallel plan B option will be needed.	Reil	I&T	11-Nov-16	1	3	4	1	3.2	Insignificant	Study	RAFT integration plan B	1) develop a plan B design solution. Plan B vendor is leading the plan B design effort but additional design effort at SLAC and additional procurements would be needed. Plan B is being developed within the existing scope. If risk is realized additional costs will be incurred. (DONE) 2) procure commercial 3-axis stage early while full performance stage if fabricated at the vendor to perform early testing with software.		Accepted	10/2016 Initial Entry..Plan b preliminary designs are mostly in hand with relatively little overrun in actual costs. Plan A seemed highly prefered by review committee at TDR. 2/2017 Plan A has made sufficient progress that we are increasingly confident that plan B will not be needed. 11/2017 Plan B has been dropped. 11/2017 Mitigation is complete. Move to accepted		6/1/2016	8/1/2017	1	3	4	1	3.2	Insignificant	$200	$200	$1,500	Cost for execution of plan B (hexapod) solution or new plan. Hardware itself would be mostly vendor delivered.	3.0	4.0	6.0		0%	1%	$0	$2	$33	2.08	0.00	0.04	0.06
Crnr Rft	3.04.02.03.03	Crft-011	CCD Guide Sensor binning	If science raft CCD binning cannot be performed in the serial register direction THEN binning requirement may not be met.	Herrmann	ETU	5-Jun-15	2	1	1	2	3.0	Insignificant	Study	Test science raft CCD in guider binned readout mode	Run science raft CCD in guide readout mode with binning (still pending as a test)		Working	7/2013: discussion started with BNL on binning capabilities 01/2015: this will be tested in the guide sensor test bed 05/2015: this test will be done at the same time Crft-010 testing will be done in the June/July 2015 timeframe. 04/2016: binning has not been done at this time. Risk is not expected to be high			2/1/2018	2/1/2018	1	1	1	2	1.5	Insignificant	$0	$0	$30	Use as is	0.0	0.0	0.5	Use as is	0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
EXCH	3.06.03	EXCH-037	Impossible alignement of the Filter sub-systems	If the sub-system can not be together aligned. THEN all the sub-systems need to be dismounted for the adjustment and the modification, the camera integration will be shifted.	Karst	I&T	16-Jun-17	1	2	3	3	3.0	Insignificant	Study	Alignment Plan	Define an Alignment Plan with a real part as the camera absolute reference, adjust all the mechanisms in respect with the absolute reference. Test the alignment in France before the shipment in US.		Working	05/2018 : A first Assembly of the dummy camera has been done in April. The first test of the Carousel with the Auto Changer is foreseen in May. 02/2018 : The delivery of the Dummy Camera is delayed to mid of March. The combined test is postponed to April 2018. 11/2017 : The delivery of the Dummy Camera is estimated end of february 2018. The combined test is postponed to March 2018. 05/2017 : The assembly of the sub-systems together is posponed on Automn 2017 01/2017 : The assembly of the sub-systems together is planned on summer 2017 9/2016 : Combined test postponed to March 2017. 6/2016 : The assembly of the sub-systems is delayed by three months, the combined test is postponed to December 2016. 5/2015: The system will be tested in France before shipment at SLAC, for any alignment problem, we will solve it before the integration on the camera. The first alignement is planned on the Full Scale Prototype in October 2016 3/2014 : The camera integration has been define using fiducial. On the subsystems, fiducials will be used firstly to adjust the interfaces parts, and secondly to ajust the subsystem on the camera. The adjustment specification are defined (LCA-49). 09/2013 : Initial definition	EXCH Shipment	June 18	8/1/2019	2	1	2	1	3.0	Insignificant	$0	$0	$30		0.5	1.0	1.5		1%	5%	$0	$0	$1	0.15	0.01	0.05	0.08
Crnr Rft	3.04.02.04	Crft-019	ITL Wavefront sensor readout speed	IF the LSST readout electronics cannot achieve the 550kp/s readout speed on the ITL wavefront sensors THEN the wavefortn sensor will not be readout in the 2 sec time requirement	Herrmann	Design	24-Aug-15	2	1	1	2	3.0	Insignificant	Proto	Test ITL sensors with electronics, design an active flex cable	Test the WGREB board with ITL WFS sensors, diagnose cause for slow readout and increased noise, design an active flex cable to mitigate the slow readout time (this was done with the EM versions)		Accepted	8/2015: test with the WGREB demonstrated that 550kp/sec could not be reached with good noise performance. Additonal testing is under way. Adding an active circuit to the flex cable is a solution (not funded yet for procustion) that has been identified and is actively worked on at BNL under science raft scope. 10/2015: progress has been done investigating the issue. the WGREB prototype design has been updated to test a mitigation. The flex cable has been re-designed to reduce capacitance. 11/2015: test conducted with the active flex cable design showed adequate performance. probability of not being able to meet performances is reduced. 01/2016: test conducted at BNL showed that it is possible to meet speed, noise and power with the active flex cable on ITL science sensors. Cost of the flex will be absorbed by the corner raft. 04/2016: WFS first article expected on 09/2016 (delayed). Test will be conducted when a readable WFS is received from ITL. 09/2017: testing was completed at SLAC with EM boards at the end of spring 2017. No more mitigations planned. Risks is accepted.		12/1/2016	10/1/2016	2	1	1	2	3.0	Insignificant	$0	$25	$30		0.0	0.3	0.5		1%	5%	$0	$1	$4	0.65	0.00	0.01	0.03
Sci Rft	3.03.02.03	Srft-073	Non-uniform Sensor shipments	If one or both Sensor vendors do not supply CCDs in a uniform and well coordinated manner, THEN too many Sensors may arrive in a short period of time making it too difficult to meet the Sensor acceptance schedule.	Wahl	Procure	8-Nov-16	2	1	2	1	3.0	Insignificant	Anal	Optimize CCD Qualification Plan	1) Determine a realistic sample size to measure and rely on vendor data for the rest. 2) Negotiate longer lead times for payment		Accepted	4/15/17 After experiencing the delivery of over 20 Sensors in March 2017, it is clear we can qualify large quantities of Sensors in a relatively short amount of time assuming we stick with the baseline plan of testing 10-30% of the CCDs at TS3 (EO) and 100% metrology at TS2. Based on this experiance, the probability assignment is now reduced to 2. 11/14/16 There is a reasonable likelihood that Vendor 1 will deliver many devices in January 2017 (approximately 17). The Science Raft team is capable of performing EO measurements at a rate of 2-3 devices per week, which translates to approximately 5 weeks of measurements. It is likely some fraction of the Sensors will need to be accepted based on EO vendor data alone. Metrology will be performed on all devices, which is easily achievable.	End of CCD procurement phase	8/15/2018	10/1/2016	2	1	2	1	3.0	Insignificant	$0	$0	$30	There is no residual cost if we decide to test fewer devices.	0.5	1.0	1.5	There are no residual delays if we decide to test fewer devices.	1%	5%	$0	$0	$1	0.15	0.01	0.05	0.08
I&T	3.08.06	IT-028	ComCam Vibration	IF cryotel coolers induce more vibration than can be accepted THEN additional damping will be needed.	Reil	I&T	10-May-18	1	3	3	1	2.8	Insignificant	Proto	Testing	1) ComCam TDR reccomendation to procure and test with cryotels ASAP to determine if more mitigation needed 2) Cryotels being were purchased with active vibration control.		Working	Initial Entry. Vibration in cryotel is a known issue. Units have been successfully used in imagers with more problems in spectrograph applications. Initial Tests in IR2 are promising.		8/1/2018	8/1/2018	1	1	1	1	1.2	Insignificant	$0	$20	$30	If a problem is discovered more damping design work is needed but not expecting significant issues post mitigation. No problem currently expected. If one still pops up schedule will be hard to meet.	0.0	0.5	0.5		0%	1%	$0	$0	$1	0.09	0.00	0.00	0.01

LSST Camera Risk Registry

Risk Identification							Current Assessment							Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)			
									Impact of Risk				Exposure Level									Impact of Risk				Exposure Level																			
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
EXCH	3.06.03	EXCH-018	Carousel circular rail failure	IF the Carousel circular THK rail system fails or jams, THEN filter exchange capability would be lost	Karst	Fab	16-Jun-17	1	1	4	2	2.5	Insignificant	Proto	THK rail test bed	Design rail system with safety margin; Life test with full scale prototype		Working	02/2018 : The Long duration test with particule measurement is planned in 2019. 09/2017 : The first result of the long duration test is expected in July 2018 05/2017 : The Carousel has been tested in all the load and angular configuration, it work well without any jam. Then the reliability in time will be tested with the long duration test. 01/2017 : The load test is postponed in January 2017. 9/2016 : The test with themaximu load in the worst case is planned in November 2016 8/2016 : The cold test of the THK rail fixation have been performed with positive results. The parts keep aligned and clamped on the Back Flange. 7/2015: Updated calculation results : Under nominal max load and Temperature variation, the rail misalignement keeps in the range of 10 µm. 5/2015: The life test under load is planned in October 2016 10/2014 : The last modifications of the design include the needed degrees of freedom for the Ring gear which is made of steel. The design is now compliant with the temperature variation. the overall calculation results confirm the design. 08/2014 : The new design takes into account of the differential shrinkage from the Back Flange to the ring gear. Finite element Analysis has yet to be done. 03/2014 : A new concept is under study 02/2014 : The calculation results confirm the rail and fixation don't withstand to the load under the temperature vartiation. A new design of the rail fixation is needed. 11/2013 : At the PDR, the design didn't take into account of the differential expansion. 10/2011: preliminary structure analysis done, margins OK (increase with the structure stiffness, cf. EXCH-015)	EXCH Proto test	9/1/2019	3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$30	offset cost	0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
Cryo	3.06.04.06	Cryo-074	Utility Trunk Refrigeration Lines on the top end	IF the refrigeration lines on the top end of the Utility Trunk cannot meet stayclear requirements, THEN additional design and mock-up will needed to resolve the issue				2	1	1	1	2.3	Insignificant			1) Review requirement impact and adjust if possible 2) Add additional compliance to the line length		Working	2/2018: Based on the mock-up, a small violation of the stayclear exists, but can be mitigated. 10/2017: The stayclear volumn as changed once due to better understanding of the stayclear requirement. Additional review of the requirement is necessary. The hoses may not meet minimum bend radius requirements.			10/12/2017	2	1	1	1	2.3	Insignificant	$0	$30	$30		0.0	0.0	0.5		1%	5%	$0	$2	$4	0.75	0.00	0.00	0.03
I&T	3.08.06	IT-029	ComCam ETU2	IF ETU is damaged prior to AVAIL for ComCam THEN an alternative RAFT will be needed	Reil	I&T	8-May-18	2	1	1	1	2.3	Insignificant	Study	WPC for ETU handling	0) Either ETU can be used. Pick better of two. 1) All RAFT handling in I&T including for ETUs follows strict work planning and control (IN PLACE) 2) Use RTM22 (spare raft) as ComCam (NOT ELECTED YET)		Working	Initial Entry: Since ETU2 is used for commissioning the RAFT acceptance tests and used for commissioning cryostat integration in I&T a recent ComCam review indicated this was a potential risk that should be addressed.	AVAIL: ETU2 for ComCam	6/1/2018	1/1/1900	1	1	1		0.8	Insignificant	$0	$30	$30	Cost of repairing ETU2 or retrofitting ETU1 (if the RTM22 mitigation is not successful or desired anymore)	0.0	0.5	0.5	time for the repair or retrofit	0%	1%	$0	$0	$2	0.13	0.00	0.01	0.01
Cam	3.01	CAM-007	Procurement delays < 1.5 months	IF hardware or subcontract procurements are delayed or held up, THEN schedule delays could affect L1 delivery milestones (Note: optics and sensors are excluded, and itemized separately)	Riot	Procure	15-Jul-15	1	3	1	1	2.2	Insignificant	Study	Trend procurement performance	Track and trend procurement performance in PMCS; shift procurements to other institutions within collaboration to bypass problem areas. Plan in manageable float between L3 and L4 (not necessarily a standard, but based on possible element delays, roughly 6 months)		Working	07/2017: the project is tight on schedule, although the project still maintains healthy scehdule contingency (12 months to operation and 22 to CD-4). Current risk of missing CD-4 is still low 8/2016: The project is doing fine on SPI and there is healthy contingency to L1 milestones ~23 months. Currently we have not slipped schedule sincd CD-2. 5/2016: as more items were itemeized seprately and are under contract, the probability was reduced to a 5. 8/9/2014: More items were itemized separately (Grid & CABAC) 4/9/2014: Refined risk by milestone levels. Maintain minimum 120 days of float on all non sensor L4 activities. Start procurements early. 9/2011: P6 schedule completed using published procurement process times and vendor quotes for lead times on major items. 4/2011:Incorporating procurements explicitly in project schedule for tracking; procure plan awaits baselining with the rest of the schedule	CD-4	6/1/2020	6/1/2017	1	3	1	1	2.2	Insignificant	$200	$215	$860	5/2018: 5% of remaining procurement ($4.3M) cost as of 4/2018 except for sensors and optics which have itemized risks listed. Worst Case 20%. 3/2018: 5% of remaining procurement ($5.5M) cost as of 3/2018 except for sensors and optics which have itemized risks listed.	0.0	0.5	0.5	All major procurement except for the shutter blades are in place	0%	1%	$0	$2	$24	1.60	0.00	0.01	0.01
ELX	3.08.03	ELX-005	Thermal Control Loop	If raft thermal control loop is not stable then camera will not meet performance requirements.	Haller	Design	7-May-18	1	1	2	3	2.2	Insignificant	Proto	Thermal Control Loop	Include in testing when quadrant box is instrumented		Working	5/7/18: same as last update 8/6/16: if there is any risk in the raft feedback loop not working, although there have no tests. The plate feedback has not been tested with the current refrigerator design. It worked great with a previous configuration. The risk is that the refrigerator responds in a nonlinear, perhaps time dependent manner, and the feedback loop becomes unstable. The present tests are showing the plate temperature being nearly independent of the heat load and settling times after changes of nearly a day. If the plate temperature is constant, but uncontrollable, the raft loops may run out control range. 11/14/2013: Software implementation of PID control loop - simulations to date show very long time constants and high gain - implies a very stable and simple loop. Subsystem test stands use common SW implementation. Still working on protection PLC's, thermal control for CCD's, cryo, cold, camera purge, UT cooling 3/2013: Draft CCS subsystem requirements documents have been written (some more mature than others).		6/1/2018	9/1/2018	1	1	1	1	1.2	Insignificant	$0	$10	$30		0.0	0.0	0.5		0%	1%	$0	$0	$1	0.06	0.00	0.00	0.01
EXCH	3.06.03	EXCH-024	Carousel gearbox failure	IF motor, gearbox or drive train component fails, THEN filter exchange capability would be lost	Karst	Fab	16-Jun-17	1	2	1	2	2.0	Insignificant	Proto	Drive train prototype	Full scale prototype of drive train for testing stresses, load distribution; easy access to replace components		Working	02/2018 : The Long duration test with particulate measurement is planned in 2019. 05/2017 : The Load Test has been performed without any isssue with the gear box. Other result will be seen with the long duration test. 01/2017 : The load test is planned in January 2017 11/2016 : Results expected in November 2016 5/2016 : The driving system assembly has started. 5/2015 : In the final Design gear boxes can be easily change. The test on the Full Scale Prototype is planned in October 2016. 4/2013: design study is complete; carousel prototype is under development 3/2011: compare with EXCH-020 4/2010: part of drive train analysis	EXCH Proto test	9/1/2019	3/1/2020	1	1	1	1	1.2	Insignificant	$0	$0	$30	offset cost	0.0	0.0	0.5		0%	1%	$0	$0	$0	0.03	0.00	0.00	0.01
I&T	3.08.01	IT-008	Personnel Ramp-up	IF personnel cannot be brought into I&T to match the budget ramp-up, THEN I&T development work will be delayed and readiness impacted	Bond	Mng	14-Jul-16	1	2	2	1	2.0	Insignificant	Study	Identify personnel early	1) Hire junior staff members to train them early		Working	11/2017: risk partially realized in FY16 and recovered in FY17. I&T budget is going down in FY18 and onwards. 6/2016: Lost key team member (CAM). 2/2015: requisition for additional help in place. 2/2014: requisition for Engin Mgr at SLAC HR; other candidates identified	CD-4		10/1/2016	1	2	2	1	2.0	Insignificant	$30	$150	$200		0.5	1.5	1.5		0%	1%	$0	$2	$10	0.69	0.00	0.02	0.02
Cryo	3.06.04.06	Cryo-065	Cryoplate evaporator flowrate	If the cryoplate evaporators have significantly different flow rates, THEN the refrigeration team will require more time in IR2 to tune the operation of each cryo refrigeration system.	Callen			1	1	1	1	1.2	Insignificant			1- Cryostat perform testing to validate if this is a risk		Accepted	7/2017: There is no obvious solution to fix the problem.			8/1/2017	1	1	1	1	1.2	Insignificant	$0	$15	$30		0.0	0.5	0.5		0%	1%	$0	$0	$1	0.08	0.00	0.01	0.01

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Risk Identification							Current Assessment							Mitigation Plan					Target Retirement			Residual Risk: Post-Mitigation Assessment						Post-Mitigation Cost (k$)				Post-Mitigation Delay (mo.)				Residual Probability		Contingent Cost (k$)				Contingent Delay (mo.)		
									Impact of Risk				Exposure Level										Impact of Risk				Exposure Level																	
SS	WBS	SS ID	Risk Title	Risk Description (if/then)	Owner	Phase	Status Date	Prob ability	Cost	Schd	Perf	Score	Current Exposure	Type	Mitigation Title	Mitigation Description	Unfunded Cost	Status	Status Description	Milestone	Date	Date Will Occur	Prob ability	Cost	Schd	Perf	Score	Residual Exposure	Min	Expect	Max	Comments	Min	Expect	Max	Comments	Min	Max	Min prob* exp cost	Max prob* exp cost	std	Mean	Min prob* exp delay	Max prob* exp delay	Max Prob* Max Delay
Sci Rft	3.04.01.02	Srft-066	RSA mechanical	IF the RSA does not meet tolerance THEN assembly will be delayed	Wahl	Procure	18-Apr-16	1	1	1	1	1.2	Insignificant	Study	Vendor Produces Replacement Units & Draw From Inventory Including ETUs	4/18/16 1. Draw from current stock including Base Plates that are slated for ETUs (2) 2. Require vendor to re-manufacture new units that meet specification. Note: Removed CE7 mitigation strategy. 6/3/15 1. Work with vendor to understand manufacturing and inspection process. 2. Manufacture from Ce6 material		Accepted	9/11/17 All of the RSA Base Plates have been received with many of them having a 1-2 micron departures below the specified thickness. In general, the Sensors are being constructed at the nominal height so the probability of the RSA not meeting absolute height requirements are low. 1/17/17 A total of 12 Raft Base Plates have been accepted to date. Some non-conformances have been observed but nothing that would impact the quality of the assembly (subtle issues only). It should be noted that all have met Absolute Height and critical hole diameter and true-position requirements. 10/18/16 In addition to the two First articles mentioned below, the vendor has produced two production Raft Base Plates that are acceptable for RTM construction (will be used for RTM#1 & RTM#2). The vendor has completed another 6 Rafts, which are awaiting approval for shipment, which is likely based on the vendors metrology reports. 4/18/16 Vendor has manufactured two acceptable First Article units, which could be used for SR production. The production order will be issued in April '16 for (24) units, which will include 2 extra BAse Plates. 12/1/15 B. Wahl & P. Takacs visited ECM in October 2015, where they met with ECM management as well as JFA (precision metrology firm). B. Wahl & P. Takacs were quite satisfied	Receipt of final Base Plate from Vendor	8/15/2017	9/1/2017	1	1	1	1	1.2	Insignificant	$0	$0	$200		0.0	0.0	0.5		0%	1%	$0	$0	$3	0.17	0.00	0.00	0.01