	Document # **LCA-125-ZH** *Author(s)* V. Riot C. Brackett	*Status:* LSST Camera APPROVED Effective Date 11 June 2019
	Subsystem/Office Project Office	

Document Title

LSST Camera WBS Dictionary

Purpose

This document captures the complete Work Breakdown Structure for the LSST Camera Project

Routing

Approvals for ZH – V. Riot, B. Wahl, M. Nordby, J. Wolfe, T. Johnson, T. Bond

References

	Revision A
10-Oct-11	Updated in preparation for CD-1. Draft 8 introduces a view of the WBS dictionary that rolls elements up to their nearest cost account; See Sheet 3.
14-Oct-11	Corrected title of WBS element 3.08.
	Revision B
30-Jul-12	Cleaned up display, updated WBS structure tab to reflect latest science raft/corner raft design.
	Revision C
18-Apr-13	Updates to present at Sensor FDR.
	Revision D
20-May-13	Added 3.08.04 Camera Test Data Handling.
20-May-13	Updated System Integration WBS Dictionary 3.02.
	Revision E
31-Mar-14	Split Sensors into 3.03. Combined Science and Corner Raft under 3.04.
21-Apr-14	Presented at CD-3A.
	Revision F
31-Mar-14	Split Sensors into 3.03. Combined Science and Corner Raft under 3.04.
18-Sep-14	Prepared for CD-2.
	Revision G
29-Sep-14	Corrected deliverables in 3.04.01.02.01.
	Revision H
25-Jan-16	Release incorporating all changes made since BCR-001.
1-Feb-16	***Released per LCN-1512.***
	Revision I
15-Aug-16	Release incorporating BCR-028 new scope for Science Raft and Corner Raft, and BCR-023 I&T description update to 3.08.01 and split of 3.08.02, 3.08.03, 3.08.04. Also, updates CAMs for I&T.

	Revision J
29-Sep-16	This release includes the following BCR's: - BCR-032, updated CAM for project management (all of WBS 3.01) and Science Sensor Procurement (control account 3.03.02.02). - BCR-033, removes SBEO test stand from I&T (3.08.02.01.02) To be planned by the Corner Raft sub-system on a later BCR. - BCR-034, adds test stand 7 & 8 (SBEO) to the corner raft sub-system (3.04.02.02) and adds back the SBMS back into the I&T scope (3.08.02.01.01). *- Release approved per LCN-1655*
	Revision K
14-Oct-16	This release includes the following changes as described in BCR-036: - Add REB5 CCS support, Camera Rotator HCU, and I&T Environment Monitoring and Displays. - Add engineering overight at Witness Points per SOW LCA-13383 for the BBAR coating.
31-Oct-16	*Approved per LCN-1682.*
	Revision L
16-Nov-16	This release includes the following changes: - BCR-037 - Updated CAM for control account to 3.03.02.02 to Tom Markiewicz. - BCR-040 * Sensor CAM Scope. * SR Scope Changes. * CBM testing Scope. * AE add'l boards Scope.
5-Dec-16	*Approved per LCN-1721*
	Revision M
14-Dec-16	This release includes the following changes: - BCR-041 - Sensor vendor and sensor test replan.
18-Jan-17	*Approved per LCN-1737.*
	Revision N
17-Jan-17	This release includes the following changes: - BCR-042 - CAM change for the cryostat and utility trunk WBS (3.06.04 & 3.06.05). - BCR-043 - Added new scope to Optics.
30-Jan-17	*Approved per LCN-1742 & LCN-1743.*
	Revision O
6-Mar-17	This release includes the following changes: - BCR-046 - Com Cam replan WBS (3.08.06).
17-Mar-17	*Approved per LCN-1774.*
	Revision P
14-Mar-17	This release includes the following changes: - BCR-048 - Cryostat Refrigeration Replan WBS (3.06.04.06).
30-Mar-17	*Approved per LCN-1777*
	Revision Q
10-Apr-17	This release includes the following changes: - BCR-049 - Science Raft Enhanced shipping (3.04.01.06). - BCR-049 - B33 and B660 security upgrade (3.08.04). - BCR-049 - Improved Flex Cables for ITL Science Rafts (3.03.02.02). - BCR-049 - CCS Travel for FY18 (3.07.01.01).
20-Apr-17	*Approved per LCN-1790*

	Revision R
9-May-17	This release includes the following changes: - Updated the wording in WBS (3.06.05.02) per sub-system PDR - BCR-051 - Integrated Thermal Analysis support of Refrig requirements WBS (3.02.02). - BCR-051 - IR2 Pump/Leak Check Cart and MF06 for RAFT's WBS (3.08.02, 3.08.04). - BCR-051 - REB5 Boards and Refurb of REB Production RGA Station WBS (3.04.01.03). - BCR-052 - ITL Long lead Material Supplement Yield Mitigation WBS (3.03.02.02).
25-May-17	*Approved per LCN-1813 & LCN-1819*
	Revision S
21-Jun-17	This release includes the following *May17* changes: - BCR-053 - Added new scope to UT Thermo-Mech & Assy WBS (3.06.05.02). - BCR-054 - Optics Scope Update WBS (3.05.02) & (3.05.04).
17-Jul-17	*Approved per LCN-1872.*
	Revision T
20-Jul-17	This release includes the following *Jun17* changes: - BCR-055 - CAM change from K. Reil to T.Bond for I&T WBS (3.08.01, 3.08.02, 3.08.03 & 3.08.04). - BCR-056 *Added new scope to DAQ Hardware and Software WBS (3.07.02.02). *Added new scope to Transportation & Storage Equipment WBS (3.08.05).
27-Jul-17	*Approved per LCN-1896*
	Revision U
16-Aug-17	This release includes the following *Jul17* changes: - BCR-059 - New scope to develop "transition to operations" plan and Pathfinder effort CCS & DAQ WBS (3.08.06). Also, broke WBS 3.08.06 into 6 additional WBS levels.
29-Aug-17	*Approved per LCN-1927*
	Revision V
15-Sep-17	This release includes the following *Aug17* changes: - BCR-061 #1 - Additional scope to assess contamination compliance of sub-systems per WBS (3.02.01). - BCR-061 #2 - Additional scope needed for PMCS support thru FY18 WBS (3.01.02). - BCR-061 #3 - Additional travel budget for UK collabrators WBS (3.07.01.01).
15-Sep-17	*Approved per LCN-1954*
	Revision W
3-Oct-17	This release includes the following *Sep17* changes: - BCR-063 - Additional scope update needed for L1-L2 Assembly WBS (3.05.03). - BCR-064 - PM and Sub System CAM Re-Org WBS (3.01.01, 3.02.01, 3.04.02.01, 3.06.01/02, 3.06.04/05 & 3.07.03.01).
25-Oct-17	*Approved per LCN-1975*

	Revision X
23-Jan-18	This release includes the following *Oct17, Nov17 & Dec17* changes: - BCR-062 - CAM changes for the following: From Vincent Riot to Martin Nordby for (All 3.02 WBS Levels), From Vincent Riot to Sven Herrmann for (All 3.04.02 WBS Levels), From Martin Nordby to Marco Oriunno for (3.06.01 & 3.06.02 WBS Levels). - BCR-065 #2 - New scope added for new sensors from E2v and additional scope to manage effort for WBS (3.03.02.02). - BCR-066 #1 - Fall-Out Sensors from E2V for WBS (3.03.02.02). - BCR-066 #2 - COB Hardware Components for WBS (3.07.02.02). - BCR-066 #3 - New scope added for Science Raft Sub-System Scientist and Deputy PM for WBS (3.04.01.01). - BCR-068 #1 - New Scope for UT Quad Box for WBS (3.06.05.02, 3.07.01.03, 3.07.02.02, 3.07.03.02 & 3.08.02). - BCR-068 #2 - New Scope for Cryo Cold System for WBS (3.06.04.06). - BCR-068 #3 - Cryostat Replan, vendor procurement updates and additional scope for lead engineer for WBS (3.06.04.01 & 3.06.04.06). - BCR-069 #1 - Descope of Shipping Container for WBS (3.08.05). - BCR-069 #2 - Descope of Commissioning Baseline Planning for WBS (3.08.06). - BCR-070 #1 - DAQ Guiding Data System new lower WBS (3.07.02.02). - BCR-070 #3 - L1_L2 Optics Shipping, new scope for shipping container design updates for WBS (3.05.03). - BCR-070 #4 - Augmented I&T BOT and Gantry Testing for WBS (3.08.02 & 3.08.03).
15-Feb-18	*Approved per LCN-2041.*
	Revision Y
23-Feb-18	This release includes the following *Jan18* changes. - BCR-071 #1 - Scope updated to cover unexpected upgrades needed to support LSST activities in IR2 WBS (3.08.04.03).
26-Feb-18	*Approved per LCN-2055.*
	Revision Z
21-Mar-18	This release includes the following *Feb18* changes. - BCR-072 #1 - Scope updated for work necessary to switch the 3x REB-4 electronics boards currently in ETU#1 to REB-5 versions WBS (3.08.02). - BCR-072 # 3 - Scope added for tasks that were originally planned to be performed and funded by contributed support but are now on project WBS (3.07.03.02). - BCR-072 # 4 - Scope added for the Cryostat and Utility Trunk Controller Board design and procurement WBS (3.06.05.02 & 3.07.03.02).
	Approved per LCN-2077.
	Revision ZA
16-Apr-18	This release includes the following *Mar18* changes: - BCR-073 - CAM changes for the following: From Scott Winters to Justin Wolfe for (All 3.05 WBS Levels).
17-May-18	*Approved per LCN-2092*
	Revision ZB
17-May-18	This release includes the following *Apr18* changes: - BCR-076 #1 - Additional Scope necessary for I&T in WBS's: 3.08.02, 3.08.03 & 3.08.04. - BCR-076 #2 - Installation Support added for Auxiliary Electronics per in WBS: 3.07.03.02.
23-May-18	*Approved per LCN-2105*
	Revision ZC
5-Jun-18	This release includes the following *May18* changes: - BCR-077 #2 - Aux Elec Test Support in WBS 3.07.03.02
27-Jun-18	*Approved per LCN-2137*

	Revision ZD
20-Aug-18	This release includes the following *July18* changes: - BCR-080 #1 - I&T Scientific Intern Support in WBS 3.08.01. - BCR-080 #2 - Cryostat Power Feedthrough in WBS 3.06.04.05. - Admin Change - revised this table to remove LCN references and any confusion (some LCN references were related to scope approvals via the LSST baseline change control process and other LCN references were noting the BCR approval/routing LCN).
18-Sep-18	*Approved per LCN-2172*
	Revision ZE
20-Sep-18	This release includes the following *August18* changes: - BCR-081 #1 - Added new lower level WBS 3.07.02.02.16 for Remote FPGA Reprogramming - BCR-081 #2 - DAQ New Layout for the COB in WBS 3.07.02.02 - Administrative updates in response to Surveillance CIO*2
27-Sep-18	*Approved per LCN-2192*
	Revision ZF
18-Oct-18	This release includes the following September18 changes: - BCR-082 #1 - Cryostat REB Power Feedthrough Cable (WBS 3.06.04.05) - BCR-082 #2 - Upgrade to Vacuum System Design (WBS 3.08.03, 3.06.04.05, 3.06.05.02, 3.07.03.02) - BCR-082 #3 - SR Upgrade Support - Load Positioner (WBS 3.08.03, 3.08.04) - BCR-082 #4 - Descope of Camera Saddle Stand (WBS 3.08.04)
28-Nov-18	This release includes the following October 18 changes: -BCR-084 #1 - IN2P3 (French Contribution) Update (WBS 3.03.02.02) -BCR-084 #2 – Reconstruction of Science Rafts (WBS' 3.08.03, 3.04.01.06) -BCR-084 #3 – New Scope for SR Scientist (WBS 3.04.01.01) -BCR-084 #4 – New Scope for Vacuum PLC Changes)WBS 3.06.04.05) -BCR-084 #6 – Activity Replan for IN2P3 Funding (WBS' 3.06.04.06, 3.07.01.02)
21-Dec-18	*Approved per LCN-2278*
	Revision ZG
21-Dec-18	This release includes the following December 2018 changes: -BCR-085 – Change CAM and WAD's update for Cryostat & Utility Trunk Control accounts (WBS' 3.06.04.01, 3.06.04.02, 3.06.04.03, 3.06.04.04, 03.06.04.05, 3.06.04.06, 3.06.05.01, 3.06.05.02)
19-Feb-19	*Approved per LCN-2307*
	Revision ZH
21-Feb-19	This release includes the following January 2019 changes: -BCR-086 – RTM Replan – Addresses new scope necessary to repair and mitigate the channel/pixel loss (WBS' 3.01.01, 3.01.02, 3.01.03, 3.02.01, 3.04.01.01, 3.04.01.06, 3.08.01, 3.08.03, 3.08.04) -BCR-087 #1 – Additional scope for L3 Vendor Contract Update (WBS 3.05.04) -BCR-087 #2 – Pending BCR Update, additional scope for project support (WBS' 3.01.02, 3.02.01, 3.05.01, 3.07.01.01)
6-May-19	This release includes the following March/April 19 changes: -BCR-088 #1 – RTM1 Remediation & Reverification (WBS 3.08.03) -BCR-089 – RTM11 Repair & Reverification (WBS 3.08.03)
11-June-19	*Approved per LCN-2463*

LSST Camera WBS Structure

WBS Code	WBS Name
3	**LSST Project - MIE**
3.00	**Project Milestones**
3.00.01	DOE Project Milestones
3.00.02	NSF Watched Milestones
3.00.03	NSF Interface Milestone (NSF Needs)
3.00.04	NSF Interface Milestone (Camera Needs)
3.00.05	Upscope/Descope Decision Points
3.00.06	NSF New Interface Milestones
3.00.07	NSF New Interface Milestones (Watch)
3.01	**Management**
3.01.01	Project Management
3.01.01.01	Project Office
3.01.01.02	Reviews & Collaboration
3.01.02	Project Support
3.01.03	Performance Safety & Assurance
3.01.03.01	ES&H, System Safety
3.01.03.02	Quality Assurance
3.01.03.03	Configuration Management
3.02	**Systems Integration**
3.02.01	Systems Engineering
3.02.02	System Integration & Analysis
3.02.02.01	Structural System Analysis
3.02.02.02	Mechanical Integration
3.02.02.03	Thermal and contamination system analysis
3.02.02.04	Optics system analysis
3.03	**Science Sensors**
3.03.01	Science Sensors
3.03.02	Science Sensors Devices
3.03.02.01	Science Sensors Prototype & Development
3.03.02.02	Science Sensors Procurement
3.03.02.03	Science Sensors Acceptance
3.03.03	Science Sensors Test Stands
3.03.03.01	Sensor Receiving & Inspection (TS1) - eLog, eTraveler
3.03.03.02	Sensor Dimensional Metrology (TS2)
3.03.03.03	Sensor Electro-Optical (TS3)
3.04	**Science and Corner Raft System**
3.04.01	Science Raft System
3.04.01.01	Science Raft System Integration & Management
3.04.01.02	Science Raft Tower Module (SRTM)
3.04.01.02.01	Science Raft Tower Module (SRTM)
3.04.01.02.02	Science Raft Sensor Assembly (SRSA)
3.04.01.02.03	Science Raft Shipping Container
3.04.01.03	Science Raft Electronics
3.04.01.03.01	ASPIC
3.04.01.03.02	CABAC
3.04.01.03.03	Raft Electronics Board (REB)
3.04.01.03.04	Digital Readout Electronics Board (DREB)
3.04.01.03.05	ITL Flex Cables
3.04.01.03.06	Electronics Production Test
3.04.01.04	Raft Optimization And Readout (ROAR)
3.04.01.05	Science Raft Test Stands (Dev & Commissioning)
3.04.01.05.01	RSA Assembly (TS4)
3.04.01.05.02	RSA & RTM Warm-Cold Metrology (TS5)

LSST Camera WBS Structure	
WBS Code	**WBS Name**
3.04.01.05.03	RTM Assembly (TS6)
3.04.01.05.04	RTM Cryostat Integration (TS7)
3.04.01.05.05	RTM Electro-Optical Testing (TS8)
3.04.01.05.06	RTM Electro-Optical Testing (TS8a) For SLAC
3.04.01.05.07	Mechanical Test Stand (TS9)
3.04.01.05.08	RTM Handling Cart
3.04.01.06	Science Raft Production Assembly and Test
3.04.01.07	Science Raft Production Assembly and Test Facility
3.04.01.07.01	Cleanroom Development & Commissioning
3.04.01.07.02	Cleanroom Operations
3.04.01.07.03	ComCam and I&T Support
3.04.02	Corner Raft System
3.04.02.01	Corner Raft System Integration and Management
3.04.02.02	Corner Raft Tower Module (CRTM)
3.04.02.03	Corner Raft Sensor Assembly
3.04.02.03.01	Corner Raft Sensor Assembly (CRSA)
3.04.02.03.02	Wavefront Sensor
3.04.02.03.03	Guide Sensors
3.04.02.04	Corner Raft Electronics
3.04.02.04.01	Wavefront Electronics Board (WEB)
3.04.02.04.02	Guider Electronics Board (GEB)
3.04.02.05	Corner Raft Assembly and Test Station
3.05	**Optics**
3.05.01	Optics Integration & Management
3.05.02	Filter Assemblies
3.05.03	L1-L2 Assembly
3.05.04	L3 Assembly
3.06	**Camera Body, Mechanisms, Cryostat**
3.06.01	Camera Body
3.06.01.01	Camera Body Integration & Management
3.06.01.02	Camera Body Development
3.06.02	Shutter
3.06.02.01	Shutter Integration & Management
3.06.02.02	Shutter Development
3.06.03	Exchange System
3.06.03.01	Auto Changer
3.06.03.02	Filter Loader
3.06.03.03	Carousel
3.06.04	Cryostat
3.06.04.01	Cryostat Integration & Management
3.06.04.02	Cryostat Housing & Assembly
3.06.04.02.01	Cryostat Housing
3.06.04.02.02	Cryostat Assembly
3.06.04.03	Cryo and Cold Plates
3.06.04.04	Grid Assembly
3.06.04.05	Cryostat Backend & Vacuum Systems
3.06.04.05.01	Cryostat Back End
3.06.04.05.02	Getter Pumps
3.06.04.05.03	Vacuum Processing and Ground Support
3.06.04.06	Refrigeration System
3.06.04.06.01	Refrigeration System - Pre IR2
3.06.04.06.01.01	Refrigeration System - Pre IR2 (System Design & Integration)
3.06.04.06.01.02	Refrigeration System - Pre IR2 (Compressor Cabinet)

LSST Camera WBS Structure	
WBS Code	**WBS Name**
3.06.04.06.01.03	Refrigeration System - Pre IR2 (Long Lines)
3.06.04.06.01.04	Refrigeration System - Pre IR2 (HX)
3.06.04.06.01.05	Refrigeration System - Pre IR2 (Equipment & Refrigeration)
3.06.04.06.02	Refrigeration System - IR2
3.06.04.06.03	Refrigeration System - Chile System
3.06.04.06.03.01	Refrigeration System - Chile System (System Design & Integration)
3.06.04.06.03.02	Refrigeration System - Chile System (Compressor Cabinet)
3.06.04.06.03.04	Refrigeration System - Chile System (HX)
3.06.04.06.03.05	Refrigeration System - Chile System (Equipment & Refrigeration)
3.06.04.06.04	Refrigeration System Replan
3.06.04.06.04.01	2 Cryo/2 Cold HeX Vacuum Vessel Intgr
3.06.04.06.04.02	2 Cryo/2 Cold Heat Airside Assy
3.06.04.06.04.03	4 Cryo Heat Ex
3.06.05	Utility Trunk
3.06.05.01	Utility Trunk Integration & Management
3.06.05.02	Utility Trunk Thermo-Mechanical and Assembly
3.07	**Control System, Data Acquisition System and Auxiliary Electronics**
3.07.01	Camera Control System (CCS)
3.07.01.01	CCS Integration & Management
3.07.01.02	CCS Core
3.07.01.02.01	CCS Developer Tools
3.07.01.02.02	CCS Core Infrastructure
3.07.01.02.02.01	CCS Core 1.5 Release
3.07.01.02.02.02	CCS Core 1.6 Release
3.07.01.02.02.03	CCS Core 2.0 Release
3.07.01.02.02.04	CCS Core 3.0 Release (Support MCM)
3.07.01.02.02.05	CCS Core 4.0 Release (Support OCS/CCS Bridge)
3.07.01.02.02.06	CCS Core 5.0 Release (Support Lock Manager)
3.07.01.02.02.07	CCS Core 6.0 Release (Comcam Ship)
3.07.01.02.02.08	CCS Core 7.0 Release (Final)
3.07.01.02.03	CCS Master Control Module
3.07.01.02.04	CCS/OCS Bridge
3.07.01.02.05	CCS Lock Manager
3.07.01.02.06	CCS Database
3.07.01.02.07	CCS Logger/Monitoring and Alarms
3.07.01.02.08	CCS Human Console/Scripting Console
3.07.01.02.09	CCS Diagnostic Cluster and Visualization
3.07.01.02.10	E Manufacturing
3.07.01.03	CCS HCU
3.07.01.03.01	Rafts Subsystem/DAQ Interface and Test Stands (TS3/TS8)
3.07.01.03.01.01	REB Driver
3.07.01.03.01.02	Rafts Subsystem
3.07.01.03.01.03	Test Stand 3 (Reflex/Archon Controller Based)
3.07.01.03.01.04	Test Stand 8 (REB Based)
3.07.01.03.01.05	LPNHE CCS Electronics Test Stand
3.07.01.03.02	Refrigeration HCU
3.07.01.03.03	Cryostat HCU
3.07.01.03.04	Power Supply HCU
3.07.01.03.05	Filter/Carousel HCU
3.07.01.03.06	Shutter HCU
3.07.01.03.07	Camera Body HCU
3.07.01.03.08	I&T HCU
3.07.01.03.08.01	Single Bay HCU

LSST Camera WBS Structure	
WBS Code	**WBS Name**
3.07.01.03.08.02	BOT HCU
3.07.01.03.08.03	CCOB HCU
3.07.01.03.08.04	Gantry HCU
3.07.01.03.08.05	Camera Rotator HCU
3.07.02	Data Acquisition System (DAQ)
3.07.02.01	DAQ Integration & Management
3.07.02.02	DAQ Hardware and Software
3.07.02.02.16	Remote FPGA Reprogramming
3.07.02.02.01	Optical Transition Module (OTM) and Cabling
3.07.02.02.02	DAQ COB (Main ATCA DAQ Module)
3.07.02.02.03	FPA/SSD-RTM (Rear Transition Module with IO-Links and Drives)
3.07.02.02.04	DAQ FPA-RTM (Rear Transistion Module)
3.07.02.02.05	SSD-RTM (Rear Transistion Module, incl Drives)
3.07.02.02.06	ATCA Shelves
3.07.02.02.07	Source Communication Interface Firmware (SCI)
3.07.02.02.08	Crosstalk Correction Firmware
3.07.02.02.09	Raft Management/Data Server/Client Software (RMS/RDS)
3.07.02.02.09.01	Image Management/Server/Client Software
3.07.02.02.09.02	Raft Data Server/Client Software (RDS/RDC)
3.07.02.02.10	Timing Distribution Server Hardware&Software (TDS)
3.07.02.02.11	FPA Emulation Server Software (FES)
3.07.02.02.12	Storage Array Software (SAS/SAC)
3.07.02.02.13	DAQ Systems and Test Stands
3.07.02.02.13.00	DAQ Version 0.0
3.07.02.02.13.01	DAQ Version 1.0
3.07.02.02.13.02	DAQ OTM V2
3.07.02.02.13.03	DAQ Version 2.0
3.07.02.02.13.04	Deleted
3.07.02.02.13.05	DAQ Version 3.0
3.07.02.02.13.06	DAQ Version 4.0
3.07.02.02.13.07	DAQ Version 5.0
3.07.02.02.13.08	DAQ Engineering Test Unit
3.07.02.02.13.09	DAQ Assembled Hardware
3.07.02.02.14	DAQ PGP
3.07.02.02.15	Guiding Data System (GDS)
3.07.03	Auxiliary Electronics
3.07.03.01	Aux Electronics Integration & Management
3.07.03.02	Components
3.07.03.02.01	AC and DC Power Distribution
3.07.03.02.02	Custom Raft Supply Boards
3.07.03.02.05	Custom Heater Power Supply and RTD Boards
3.07.03.02.07	Custom DC Power Supply Chassis and Backplane
3.07.03.02.09	Shutter HCU Hardware
3.07.03.02.10	Camera body Purge HCU
3.07.03.02.11	Cryostat HCU
3.07.03.02.12	Heater Ex, UT Cooling HCU
3.07.03.02.13	Cables/Networking
3.07.03.02.14	Protection PLC System
3.07.03.02.15	Protection HCU System
3.08	**Integration and Test**
3.08.01	I&T Integration & Management
3.08.02	Verification Test Systems
3.08.02.01	Raft Acceptance Test Systems

LSST Camera WBS Structure

WBS Code	WBS Name
3.08.02.01.01	Single Bay Metrology Tests
3.08.02.01.02	Single Bay EO Tests
3.08.02.01.03	Vacuum Qualification Tests
3.08.02.02	Cryostat Test Systems
3.08.02.02.01	Bench For Optical Testing (BOT)
3.08.02.02.02	Pathfinder / Test Raft Program
3.08.02.03	Camera Test Systems
3.08.02.03.01	CCOB
3.08.02.03.02	CCOB (France)
3.08.02.04	Verification Software Development
3.08.03	Cryostat I&T
3.08.03.01	Integration Gantry
3.08.03.02	Cryostat Handling Equipment
3.08.03.03	Raft Acceptance Testing
3.08.03.04	Cryostat Assembly and Test
3.08.04	Camera I&T
3.08.04.01	Camera Integration Stand
3.08.04.02	Camera Handling Equipment
3.08.04.03	IR2 Facility and Operations
3.08.04.04	Camera Assembly and Test
3.08.05	Transportation & Storage Equipment
3.08.06	Commissioning Camera
3.08.06.01	Commissioning Camera Hardware
3.08.06.02	CCS Commissioning Camera Tucson Hardware
3.08.06.03	CCS Commissioning Camera MIE Hardware
3.08.06.04	CCS Pathfinder
3.08.06.05	DAQ Pathfinder
3.08.06.06	Commissioning Baseline Planning

Total Project Cost (TPC)

LSST Camera WBS

LCA-125

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3					LSST Camera TPC	This WBS element covers the Total Project Cost (TPC) for the LSST Camera Project, covering the Total Estimated Costs (TEC) and Other Project Cost (OPC). The LSST TPC is supported the U.S. Department of Energy and other sources.	SLAC	V. Riot	R
3	*.01*			-	*Management*	This WBS element identifies the technical and administrative management of the project. It covers establishment and operation of the Project Management Control System (PMCS), generation of financial and technical reports, and organization of technical support and reviews. Effort and supplies related to management of project-wide ES&H issues are included.	SLAC	V. Riot	R
3	.01	.01		-	Project Management	This Control Account level of the WBS includes see WBS details below. 2014-11 PMB Start **BCR-002 #6 (Correction to LOE Activity Start)** **BCR-039 (LSST Camera Re-org** **BCR-050 #1 (Outstanding Performance Annual Bonus)** **BCR-064 (PM and Sub-System CAM Re-Org)** **BCR-075 (Standing Army Scope Updates)** **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss	SLAC	V. Riot	C
3	.01	.01	.01		Project Office	This Sub-Account WBS cell includes Project Management support for the LSST Camera Project. This element captures efforts of the Project Director, Project Manager, Deputy Project Manager, Project Administrator, and Administrative Staff. Also includes related supplies and travel. **BCR-064 - PM and Sub-System CAM Re-Org**	SLAC	V. Riot	S
3	.01	.01	.02		Reviews & Collaboration	This Sub-Account WBS cell includes: The effort associated with external/internal reviews and general collaboration not identified within a specific level 2 WBS system. This element captures the effort, travel and supplies to support all project level reviews.	SLAC	V. Riot	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.01	.02			Project Support	This Control Account level of the WBS includes: The Project Management Cost Schedule (PMCS) and PMCS contractors. The scope includes the following 1. Monthly status updates within forecast schedule and tracking of project critical activities 2. Tracking changes to project baseline and impact analysis of changes 3. Supporting CAM's with variance analysis 4. Supporting CAMs and project management with EAC analysis and updates 5. Project reporting (Hammer, CSSR, CPR, actuals and other special request) 6. General support during reviews providing data to project to be included in review 2014-11 PMB Start **BCR-013 #3 (PMCS Support Scope)** **BCR-034 #4 (PM new scope for PMCS)** **BCR-061 #2 - Additional scope for PMCS support in FY18** **BCR-075 (Standing Army Scope Updates)** **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss **BCR-087 #2 – Pending BCR Update**, additional scope for project support	SLAC	V. Riot	C
3	.01	.03			Performance and Safety & Assurance	This Control Account level of the WBS includes: Performance and Safety Assurance Manager to manage the Camera performance and safety assurance program; establish and coordinate ES&H programs governing work at all collaborator's labs; develop and maintain the system safety program, including maintaining an active hazard analysis program to identify and track to closure all Camera hazards; perform reliability analyses and establish appropriate quality assurance programs; then, administer QA program for the Camera and its subsystems. ES&H: Establish and coordinate environment, safety, and health programs governing work at all collaborator's labs; work with institutional Camera project personnel, ES&H officers, subject-matter experts to establish programs appropriate to the work; establish and perform safety review programs and audit review of collaboration safety reviews; provide on-site inspection during fabrication, assembly, integration, and test. System Safety: Develop and maintain system safety program, including maintaining active hazard analysis program to identify and track to closure all Camera hazards; work with subsystems to write hazard reports as appropriate and coordinate system safety reviews with DOE, LSSTC, and institutional safety personnel. Quality Assurance: Perform reliability analyses and establish appropriate quality assurance programs; work with subsystem and institutional QA, purchasing, and project personnel to flow QA program requirements to all subsystems; administer QA program for the Camera and its subsystems; audit QA program during fabrication, assembly, integration and test; compile quality records and support I&T and SE in developing Camera acceptance test package. 2014-11 PMB Start **BCR-039 (LSST Camera Re-org)** **BCR-075 (Standing Army Scope Updates)** **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss	SLAC	V. Riot	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.01	.03	.01		ES&H, System Safety	This Sub-Account WBS cell includes: ES&H support for the LSST Camera Project. This element captures efforts of the ES&H staff and System Safety Engineer.			S
3	.01	.03	.02		Quality Assurance	This Sub-Account WBS cell includes: The effort associated with QA technical support which includes external/internal reviews and general collaboration not identified within a specific level 2 WBS system. This element captures the effort of the QA Technical Support Staff.			S
3	.01	.03	.03		Configuration Management	This Sub-Account WBS cell includes The effort associated with configuration management not identified within a specific level 2 WBS system. This element captures the effort of the Configuration Manager.			S
3	.02				Systems Integration	Manage technical development of the LSST camera; includes managing development of camera and subsystem requirements, defining internal and external interfaces and writing ICD's. Maintain configuration and risk management processes for the camera and all subsystems. Perform system-level analyses during design and verification test development; manage technical design development for structural, thermal, contamination, optical and design elements of the camera. **BCR-062 - CAM change** from Vincent Riot to Martin Nordby for (3.02.01	SLAC	M. Nordby	R
3	.02	.01			Systems Engineering	This Control Account level of the WBS includes Level of effort work to cover on-going technical management activities for the Camera project.Cost and Schedule Management of System integration: develop cost and schedule estimates for system integration effort. Implement earn value process. Risk Management: Develop and maintain camera risk registry. Work with subsystems to update status of mitigations, liens on project reserves and impacts to the camera project. Perform Monte Carlo risk analysis as part of contingency assessment process for reviews. Requirements Management: Develop, flow down, and maintain all Camera and subsystem requirements, budgets, and metrics. Develop verification plans and track subsystem and Camera-level verification activities. Develop and maintain compliance documentation. Work with Obs SE to manage requirements change process and investigation of impacts.Technical Management: (system engineer and system architect): Write and implement camera-level technical management plans and processes. Work with Obs SE's to implement LSST processes for the camera. Develop and maintain camera interface block diagrams. Coordinate and help write ICD's between subsystems; edit and manage work to resolve TBD's; revise and finalize during development process and support development of interface verification plans by subsystems. Serve as single point of contact for Camera external interfaces. generate sequence diagram, flow diagrams and operation diagrams.Configuration Management: Set up and maintain Camera CM system. Develop and maintain document control system and processes for documents and drawings. Provide on-going support for the change control process, including drafting change requests and moving them through the change process.Mechanical System Engineering: Support drafting, refinement and completion of interface drawings between sub-systems and external interface	SLAC	M. Nordby	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						drawings. Write and implement camera-level mechanical standards plans and processes. Electrical System Engineering: Write and implement camera-level electrical standards, ESD and grounding and shielding plans and processes.Software System engineering: Camera computing coordinator role. Write and implement camera-level software standards. Review Interfaces containing software components for compliance. Organize code reviews. Support code management and documentation.Thermal System Engineering: Review all interfaces related to components located in the cryostat. Ensure all ICDs and IDDs between sub-systems located within the cryostat are consistent.Travel: All travel for the subsystem is collected in this WBS element, including travel for subsystem reviews and interface meeting with LSST project personnel.Contamination coordination: coordination of contamination qualification testing for time period covering sub-systems FDR and MRR. Include maintenance of hardware necessary to complete the tests. 2014-11 PMB Start **BCR-028 #1 (New Scope, Contamination coord/MTF support)** **BCR-039 (LSST Camera Re-org)** **BCR-061 #1 - Contamination coordination and MTF support for FY18** **BCR-064 - PM and Sub-System CAM Re-Org** **BCR-075 (Standing Army Scope Updates)** **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss **BCR-087 #2 – Pending BCR Update**, additional scope for project support			

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.02	.02			**System Integration & Analysis**	This Control Account level of the WBS includes: Task based camera level analyses in support of sub-systems or part of camera level verification and validation. Structural Systems Engineering: Perform Camera-level structural analyses. Work with subsystems to specify structural interfaces, loads, and test levels. Develop, update, and maintain detailed camera structural FEA model and update with subsystem component design changes as needed in support of all subsystem, camera, and Observatory reviews. Support Obs SE with analysis of cross-interface structural response and assessment of telescope and other structural response, interfaces, and designs. Develop Camera and subsystem-level structural verification tests. Mechanical Integration: Perform Camera-level interface and stay clear verification. Update and maintain the camera integrated CAD model. Develop and generate camera level assembly drawings. Support sub-systems during the design and development phase for overall mechanical integration tasks. Thermal and Contamination Systems Engineering: Design and analyze all Camera thermal systems. Specify thermal system components for all Camera subsystems. Develop, update, and maintain detailed steady-state and transient cryostat and camera thermal models and update with subsystem component design changes as needed in support of all subsystem, camera, and Observatory reviews. Develop subsystem and Camera-level verification testing for components and full assemblies of the thermal system. Manage assembly and operations of the Camera and I&T thermal systems. Specify contamination and materials requirements for Camera subsystems. Write and maintain Contamination Control Plan, flow requirements to subsystems and manage develop of camera and subsystem standard operating procedures in response. Design and manage operations of contamination test facilities. Maintain materials and process lists for the entire Camera. Validate all materials and processes to be used on the Camera, and work with QA to verify material usage. Develop handling and cleanliness protocols for the Camera during integration and handling, and work with subsystem leads to develop protocols to be used during subsystem assembly and testing. Optics system analysis: Perform Camera-level optical analysis. Maintain the image-quality allocation budget. Maintain the camera-throughput allocation budget. 2014-11 PMB Start **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-006 #2 (L1_L2 award update for phase 2)** **BCR-011 #1 (L3 Assembly Award)** **BCR-023 #6 (Feb15 I&T Replan)** **BCR-026 #4 (Mar16 Cryostat IRR Fix)** **BCR-028 #5 (Award Update)** **BCR-028 #6 (New Scope, Addn'l Structural/Thermal Analysis)** **BCR-029 #2 (New Scope, CCS Integration Gantry)** **BCR-036 #4 (Shutter FDR Replan)** **BCR-039 (LSST Camera Re-org)** **BCR-048 (February 2017 Cryostat Refrigeration Replan** **BCR-051 #1 (Integrated Thermal Analysis support of Refrig requirements)** **BCR-056 #1 (Camera Housing Award and Scope Update)** **BCR-068 #3 (Cryostat Replan and Award Updates)** **BCR-071 #2 (Corner Raft Rephase)** **BCR-075 (Standing Army Scope Updates)**	SLAC	M. Nordby	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.02	.02	.01		Structural System Analysis	This Sub-Account WBS cell includes: Scope of work: Perform Camera-level structural analyses. Work with subsystems to specify structural interfaces, loads, and test levels. Develop, update, and maintain detailed camera structural FEA model and update with subsystem component design changes as needed in support of all subsystem, camera, and Observatory reviews. Support Obs SE with analysis of cross-interface structural response and assessment of telescope and other structural response, interfaces, and designs. Develop Camera and subsystem-level structural verification tests. Includes FEA analysis of the Carousel System prior to manufacturing readiness review. Deliverables: Finite element models for the camera, structural analysis reports.	SLAC	M. Nordby	S
3	.02	.02	.02		Mechanical Integration	This Sub-Account WBS cell describes: Scope of Work: Perform Camera-level interface and stay clear verification. Update and maintain the camera integrated CAD model. Develop and generate camera level assembly drawings. Support sub-systems during the design and development phase for overall mechanical integration tasks. Deliverables: Integrated CAD models, Stay clear models.	SLAC	M. Nordby	S
3	.02	.02	.03		Thermal and Contamination System Analysis	This Sub-Account WBS cell includes: Scope of Work: Design and analyze all Camera thermal systems. Specify thermal system components for all Camera subsystems. Develop, update, and maintain detailed steady-state and transient cryostat and camera thermal models and update with subsystem component design changes as needed in support of all subsystem, camera, and Observatory reviews. Develop subsystem and Camera-level verification testing for components and full assemblies of the thermal system. Manage assembly and operations of the Camera and I&T thermal systems. Specify contamination and materials requirements for Camera subsystems. Write and maintain Contamination Control Plan, flow requirements to subsystems and manage develop of camera and subsystem standard operating procedures in response. Design and manage operations of contamination test facilities. Maintain materials and process lists for the entire Camera. Validate all materials and processes to be used on the Camera, and work with QA to verify material usage. Develop handling and cleanliness protocols for the Camera during integration and handling, and work with subsystem leads to develop protocols to be used during subsystem assembly and testing. Deliverables: Thermal analysis and finite element model for the integrated cryostat and the camera body. Contamination plan and material specifications. **BCR-051 - Integrated Thermal Analysis support of Refrig requirements.**	SLAC	M. Nordby	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.02	.02	.04		**Optics System Analysis**	This Sub-Account WBS cell includes: Scope of work: Perform Camera-level optical analysis. Maintain the image quality allocation budget. Maintain the camera throughput allocation budget. Deliverables: Image quality budget, Throughput budget, supporting analysis reports.	SLAC	M. Nordby	S
3	.03				**Science Sensors**	This WBS element includes procurement of science sensors, program and technical management, test and characterization of R&D sensors, production testing of science sensors, and development and fabrication of production versions of Test Stand-1 (eTraveler), Test Stand 2 (Dimensional Metrology), and Test Stand 3 (Sensor Electro-Optic Testing).	BNL/ Harvard/ SLAC	V. RiotB. Wahl. T. Markiewicz	R
3	.03	.01			**Science Sensors**	This Control Account level of the WBS includes: LOE activity representing sensor technical and program management. Other support LOE activities include business operations, QA, and ES&H. **Business Operations** is responsible for generating actual reporting on a monthly basis, procurement support, support managing Harvard contract such as report generation, and support of the Project Management Control System (PMCS) generating of financial and technical reports, ensuring proper labor rates, G&A and escalation rates are applied. **Physics Manager** is responsible for coordinating sensor acceptance test data, analysis of data, and participating in sensor acceptance decisions. **BNL QA** representative will be responsible for establishing reliable procedure and defining processes for sensor acceptance and test to be performed in the BNL LSST Assembly and Test Facility. The QA representative will also be responsible for writing non-compliance reports. **BNL ES&H** representative is responsible for ensuring compliant ES&H polices are maintained in accordance with both BNL institutional policies and LSST program polices. Review and analysis of Experimental Safety Review (ESR) requirements for installation of LSST Test Stands , and assurance of compliant Operational Readiness Evaluation (ORE) for the BNL Assembly and Test Facility. Responsible for generation and analysis of hazard reports. **Travel:** All travel for the subsystem is collected in this WBS element, including travel for subsystem reviews and interface meeting with LSST project personnel **Hardware Deliverables**: None **Data Deliverables:** Basis of estimates, schedule, PCMS data, SOW generation, Institutional contracts, QA reports, ES&H reports. **2014-11 PMB Start** **BCR-020 #3 (Science Sensor/Raft Updates)**	BNL/ Harvard	B. Wahl	C
3	.03	.02			**Science Sensors Devices**	This WBS element includes procurement of science sensors, test and characterization of R&D sensors, and production testing of science sensors.	BNL/ Harvard/ SLAC	B. Wahl	R

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.03	.02	.01		Science Sensors Prototypes and Development	This Control Account level of the WBS includes: The completion of R&D activities related to the science raft sensors. Work activities are classified as laboratory setups, data analysis software development and optimization, sensor tests, documentation generation and reporting. Laboratory Setup, Software Development and Optimization: - Establish image data set specification - Development of complete set of acquisition scripts - Developed automated test report generator - Verification and validation of Data Management analysis algorithms - Verification of test stand throughput capacity - QE verification plan (how to ensure consistent measurements over time) Sensor Tests: - Low level CTE; Linearity; Full-well as a function of parallel clock voltage level; QE; Crosstalk; Crosstalk vs. readout rate; Noise vs. pixel readout rate; Tearing; Image persistence; Gain and Noise vs. VOD and VRD; Linearity vs. VOD and VRD voltages; Bright defects vs. temperature; Pixel correlations; Phased charge collection; Correlation vs. backside bias voltage; Gain and noise vs. OS current Hardware Deliverables: None Data Deliverables: Vendor compliance reports, Science Raft Design Report update, CD3a preparation (reports and presentations), CD2 preparation (reports and presentations).	BNL/Harvard	B. Wahl	C

3	.03	.02	.02		Science Sensors Procurement	This Control Account level of the WBS includes:
						The procurement of the science sensors. The sensor procurement has been broken down to two vendors and the details of quantity of sensors from each vendor are noted below. This WBS element also includes the fabrication of the flex cable necessary for use with the Vendor 2 sensors (Vendor 1 sensors come with a flex cable attached, but Vendor 2 sensors require and external flex cable). It also includes some labor to manage both vendor contracts. In particular, there was additional scope added to oversee and manage the time and material sub-contract from vendor 2.
						Hardware Deliverables:
						   - Vendor 1: 20 first article science grade sensors, 75 production science grade sensors, material for long lead option.
						   - Vendor 2: 20 first article science grade sensors, 154 production science grade sensors.
						   - Vendor 2 sensor flex cables
						Data Deliverables: Vendor sensor data and status reports.
						
						2014-11 PMB Start
						BCR-013 #4 (Sensor vendor update Scope)
						BCR-020 #3 (Science Sensor/Raft Updates)
						BCR-031 #1 (Sensor, Optics & Cryo Award/Contract Updates)
						BCR-040 #1 (Sensor CAM Scope, LCN-1675). This change captures the scope necessary to manage the second sensor vendor procurement, which was extended as a project risk mitigation. In addition, it covers the additional scope to manage a time and materials sub-contract for the primary sensor vendor.
						BCR-041 #1 (Sensor Replan). This change captures the project changing the camera focal plane from a homogeneous to a heterogeneous focal plane. The above scope description has also been modified to align with this scope change.
						BCR-047 #2 (Feb17, Sensor V1 Award Update)
							SLAC	T. Markiewicz	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						BCR-049 #4 (Improved Flex Cables for ITL Science Rafts). Addresses previously unforeseen reliability issues with the flex cables and connectors required for Science Rafts built with ITL CCD sensors. **BCR-050 #2 (IN2P3 Contribution)** **BCR-052 (CCD ITL Long lead Material Supplement Yield Mitigation)** **BCR-057 #1 (E2v Sensor Replan)** **BCR-059 #2 (E2v Letters of Credit)** **BCR-065 #2 (Science Sensor SLIN 3/CAM Support).** New scope to acquire new sensors from E2v and the additional scope to manage that effort. **BCR-066 #1 (Fall-Out Sensors from E2V).** New scope needed to acquire engineering grade sensors from e2v to use in the construction of Mechanical Test Rafts for use in verifying the performance of the integration gantry and related procedures. **BCR-070 #2 (IN2P3 (French Contribution) Update)** **BCR-084 #1 IN2P3 (French Contribution) Update -** This change addresses the shifting of budget (M&S Dollars) from a SLAC resource to a IN2P3 French contributed resource. The M&S direct dollar amount will remain the same. However, the shift of budget from SLAC resource a French contributed resource will reduce the total dollars by ~$215K.			
3	.03	.02	.03		**Science Sensors Acceptance**	This Control Account level of the WBS includes: The work scope for implementation of eManufacturing processes to track all phases of sensor acceptance at the LSST Acceptance and Test Facility located at BNL, implementation of QA, ES&H, and Hazard process to insure save handling of sensors. Sensor height and lateral metrology to verify vendor sensor package conformance. Electro-optic testing of devices to ensure vendor device performance compliance. The following sensor testing assumptions have been made:	BNL	B. Wahl	C

Within the Science Sensors Acceptance cell, the embedded assumptions table:

Phase	% Received (TS1 Receive /Inspect)	%Tested (TS8 Electro Optic)	% Tested (TS2 Metrology)
First Article	100%	100%	100%
Lot 1	100%	25%	100%
Lot 2+	100%	10%	100%
Fallout	100%	100%	100%

Hardware Deliverables: none
Data Deliverables: eTraveler data capture, sensor metrology data and reports, sensor electro-optic data and reports.
2014-11 PMB Start
 BCR-002 #5 (SR & Sensor Updates)
 BCR-009 #3 (Apr-15 Baseline Updates)
 BCR-013 #4 (Sensor vendor update Scope)
 BCR-031 #1 (Sensor, Optics & Cryo Award/Contract Updates)
 BCR-041 #1 (Sensor Replan). This change captures the impact to testing of the project changing the camera focal plane from a homogeneous to a heterogeneous focal plane. The above scope description has also been modified to align with the current scope.
 BCR-047 #2 (Feb17, Sensor V1 Award Update)

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.03	.03			**Science Sensors Test Stands**	This Control Account level of the WBS includes: The final design and fabrication of production of Test Stand 1 (eTraveler), Test Stand 2 (Dimensional Metrology), and Test Stand 3 (Sensor Electro-Optic Testing) 2014-11 PMB Start **BCR-002 #5 (SR & Sensor Updates)**	BNL	B. Wahl	C
3	.03	.03	.01		**Sensor Receiving & Inspection (TS1) - eLog, eTraveler**	This Sub-Account WBS cell includes: Activities for development of final requirements document, computer and network infrastructure equipment procurement and setup, development and definition of work-flow processes, test and validation of eTraveler at the LSST Acceptance and Test Facility located at BNL. Preparation for design reviews. Development of SOP's. **HW Deliverables:** Computer, Redhat operating system. **Data Deliverables**: Final requirements document, work flow process definition, TS1 SOP	BNL	B. Wahl	S
3	.03	.03	.02		**Sensor Dimensional Metrology (TS2)**	This Sub-Account WBS cell includes: Activities for development of final design requirements document, procurement of equipment, Qualification of equipment for installation in LSST Acceptance and Test Facility cleanroom. Final design, fabrication and test of metrology fixtures (MF01a, MF01b, MF02, MF03, MF04, MF05, MF07). Preparation for design reviews. Development of SOP's. **HW Deliverables:** •MF01a - Height metrology fixture for vendor 1 •MF01b - Height metrology fixture for vendor 2 •MF02 - Platen baseplate for metrology fixture attachment •MF03 - RSA holddown metrology fixture •MF04 - Sensor locating pin metrology fixture •MF05 - CCD Jig removal tool •MF07 - CCD cover and handling fixture **Data Deliverables:** Final requirements document, TS2 SOP	BNL	B. Wahl	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.03	.03	.03		**Sensor Electro-Optical (TS3)**	This Sub-Account WBS cell includes: Activities for development of final requirements document, procurement of equipment. Qualification of equipment for installation in LSST Acceptance and Test Facility cleanroom. Final design, fabrication and test. Development of sensor analysis scripts within DM framework. Development of automated scripting to execute suite of comprehensive sensor tests. Analysis, optimization and design of final optical illumination system design. **HW Deliverables:** Optical illumination system (e.g. photon source, monochrometer, target exchanger, dewar, CCD controller, auxiliary equipment, computer. (2) Electro-optic test stands (TS3) will be fabricated. **Data Deliverables**: Final requirements document, TS3 SOP, analysis software, analysis reports.	BNL	B. Wahl	S
3	.04				**Science and Corner Raft System**	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the science and corner raft system.	BNL & LLNL	B. Wahl, V. Riot	R
3	.04	.01			**Science Raft System**	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the science raft system.	BNL	B. Wahl	R
3	.04	.01	.01		**Science Raft System Integration & Management**	This Control Account level of the WBS includes: LOE activity representing sensor technical and program management. Business Operations is responsible for generating actual reporting on a monthly basis, procurement support, support managing Harvard contract such as report generation, and support of the Project Management Control System (PMCS) generating of financial and technical reports, ensuring proper labor rates, G&A and escalation rates are applied. The Physics manager is responsible for coordinating sensor acceptance test data, analysis of data, and participating in sensor acceptance decisions. Travel: All travel for the subsystem is collected in this WBS element, including travel for subsystem reviews and interface meeting with LSST project personnel Hardware Deliverables: None Data Deliverables: Basis of estimates, schedule, PCMS data, SOW generation 2014-11 PMB Start **BCR-015 (September Admin Changes)** **BCR-016 #4 (REB Replan/Scope)** **BCR-020 #3 (Science Sensor/Raft Updates)** **BCR-040 #2 (SR Scope Changes, LCN-1715).** Procurement of spares to maintain Test Stand operations. **BCR-066 #3 (SR Sub-System Scientist/Deputy PM).** New scope for Scientist and Deputy PM. Scientist support needed during the RTM integration phase of the project. Deputy PM support needed for FY18 to support the Science Raft PM.	BNL/ Harvard	B. Wahl	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						BCR-084 #3 - New scope for SR Scientist - • Additional scope to keep a key SR Scientists on project thru the completion of Science Raft construction. Scope includes oversight of construction efforts and results analysis RTM integration on test stands 5 and 6. **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss			
3	.04	.01	.02		**Science Raft Tower Module (SRTM)**	This Control Account level of the WBS includes: The design and development of the Science Raft Tower Module (SRTM). 2014-11 PMB Start **BCR-002 #5 (SR & Sensor Updates)** **BCR-016 #4 (REB Replan/Scope)** **BCR-026 #2 (Mar16 Science Raft Baseplate Update)** **BCR-029 #3 (Baseplate AWARD Planning)** **BCR-041 #2 (New Scope/LCN-1731, Baseplate)**		B. Wahl	C
3	.04	.01	.02	.01	**Science Raft Tower Module (SRTM)**	This Sub-Account WBS cell includes: Efforts to develop the SRTM assembly including, detailed analysis of requirements, thermal and structural simulation and analysis, molecular contamination flow analysis, shipping and handling requirements, seismic load analysis. Generation of documentation including Interface Control Documents (ICD's), requirements, assembly procedures, test reports, analysis reports. Generation of detailed manufacturing drawings. **Construction** and **analysis** of prototype SRTM including correlation of laboratory results with analytical and computer simulation models, report generation. Procurement support for prototype and production SRTM material and subcontracts. **Hardware Deliverables:** Prototype RTM. **Data Deliverables:** Test reports, ICD's, Requirements Documentation, computer models.		B. Wahl	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.04	.01	.02	.02	**Science Raft Sensor Assembly (SRSA)**	This Sub-Account WBS cell includes Efforts to develop the Science Raft Sensor Assembly Baseplate. The development effort includes detailed analysis of flowdown requirements, analysis of candidate materials, laboratory studies of candidate materials (e.g hardness tests), development of detailed drawings. **Procurement support** for prototype and production SRSA material and subcontracts. **Hardware Deliverables:** (2) prototype SRSA's, and (22) production SRSA's (SRSA is part of the SRTM assembly) **Data Deliverables:** Test reports, eTravelers, and QA documentation for each production SRSA; drawings; Metrology testing of baseplates. **BCR-041** - This change captures the needed scope to have the Raft Base Plate manufacturer grind 10 Raft Base Plates to a smaller height to facilitate the heterogeneous focal plane using Sensors from both vendors (e2v & ITL). This BCR also includes scope for one extra Base Plate. The above scope description has also been modified to align with this scope change.		B. Wahl	S
3	.04	.01	.02	.03	**Science Raft Shipping Container**	This Sub-Account WBS cell includes Efforts to develop and design a shipping container for the SRTM. The scope includes requirements analysis, design and analysis, procurement, testing and documentation. **Hardware Deliverables:** (1) First Article Shipping Container **Data Deliverables:** Test report, design documentation		B. Wahl	S
3	.04	.01	.03		**Science Raft Electronics**	This Control Account level of the WBS includes: The design integration and management costs for the science rafts electronics. This includes the effort to complete the design, simulation, fabrication and testing of the integrated circuit needed to control and readout the CCDs. 2014-11 PMB Start **BCR-002 #5 (SR & Sensor Updates)** **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-008 (Baseline Re-Plan (Buy-off) Correction)** **BCR-016 #4 (REB Replan/Scope)** **BCR-028 #4 (SR Elec New Scope)** **BCR-040 #2 (SR Scope Changes, LCN-1715)** **BCR-051 #3 (Add 'l REB5 Boards and Refurbishment of REB Prod RGA Station)**	BNL/ Upenn/ IN2P3	B. Wahl	C
3	.04	.01	.03	.01	**ASPIC**	This Sub-Account WBS cell includes: Efforts to manage, design, engineer, procure, and test the integrated circuit used to process the analog output from the CCD sensors. The functionality of the ASPIC is to pre-amplify the signals coming from the CCDs and conduct a correlated double sampling measurement before exporting the signal differential to be digitized. 18 ICs are needed per raft. **Hardware Deliverables:** 1000 ASPIC chips in their PCB package, delivered in anti-static bags. **Data Deliverables:** Design report describing ASIC design details and PCB implementation details, design files, simulation model, simulation performances, packaging procedure, measured performance measured performance characterization data performed at room temperature.		B. Wahl	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.04	.01	.03	.02	CABAC	This Sub-Account WBS cell includes: Efforts to manage, design, engineer, procure, and test the integrated circuit used to control the timing and biases of the CCD sensors. The functionality of the CABAC is to provide serial, parallel and reset clock drivers, OD, RG, OG and GD biases, internal temperature support and some analog multiplexing capability for diagnostics . **Hardware Deliverables:** 1400 CABAC chips in their PCB package, delivered in anti-static bags. **Data Deliverables:** Design report describing ASIC design details and PCB implementation details, design files, simulation model, simulation performances, packaging procedure, measured performance characterization data performed at room temperature.		B. Wahl	S
3	.04	.01	.03	.03	Raft Electronics Board (REB)	This Sub-Account WBS cell includes: Efforts to manage, design, engineer, procure, and assemble the raft electronics board. Each board is capable of controlling and reading out 3 CCDs. This covers the prototyping of the various electronics boards necessary for conducting the ROAR tests handling various versions of the integrated circuits. The board takes the data from 3 CCDs, uses the integrated circuits to interface to the sensors, digitizes the analog signals and send the data to the DAQ. The board also receives commands and timing information from the data acquisition system, and CCS. This WBS element also captures the design and development of the REB Test Facility (TS-REB) at two location (BNL and SLAC) **Hardware Deliverables:** 80 assembled and tested production REBs, 5 ROAR-1 assemblies, 5 ROAR-2 assemblies, 5 ROAR-3 assemblies, 5 ROAR-4 assemblies. **Data Deliverables:** Manufacturing QA report, production test report for each REB, contamination control plan. **Fixtures and Equipment**: REB Test Facility **BCR-040 -** To construct a total of six CCD emulators and associated cables, to allow SR, CCS & DAQ to set up a bench test virtual raft at both BNL and at SLAC. **BCR-051** - REB5 Boards and Refurb of REB Production RGA Station		B. Wahl	S
3	.04	.01	.03	.04	Digital Readout Electronics Board (DREB)	This Sub-Account WBS cell includes Effort for the design and development of the Digital Readout Board (DREB). The DREB is an intermediate design in which a small FPGA based board plugs into the REB. The functionality of the DREB will be integrated onto the REB during the REB3 design iteration. **Hardware Deliverables:** DREB1 for the REB1 version, DREB2 for the REB2. There will be no further DREB deliverables beyond the DREB2 delivery. **Data Deliverables:** FPGA Firmware, detailed design documentation.		B. Wahl	S
3	.04	.01	.03	.05	ITL Flex Cables	This Sub-Account WBS cell includes: Efforts to design, develop and manufacture flex cables used to connect the ITL sensor to the REB. **Hardware Deliverables:** (1) flex cable per sensor. **Data Deliverables:** Gerber files, flex cables.		B. Wahl	S
3	.04	.01	.03	.06	Electronics Production Test	This Sub-Account WBS cell includes: The testing of REB production boards in the BNL Assembly and Test Facility. The scope also includes the development of a test board, including design and analysis, and procurement of test equipment for the cleanroom. **Hardware Deliverables**: REB test board, test equipment (Scope, power supply). **Data Deliverables:** Test report for each REB tested.		B. Wahl	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.04	.01	.04		Science Raft Optimization And Readout (ROAR)	This Control Account level of the WBS includes: Effort related to conducting an integrating system level test In particular this includes ROAR-1, ROAR-2, ROAR-3 and ROAR-4. Scope includes ROAR test environment, dewar, temporary RTM and grid, fixtures, feedthroughs, etc. ... (Note that actual sensor, electronics, thermal strap and mechanical tower module are provided by the respective WBS element). **Hardware Deliverables**: None **Data Deliverables:** Integrated test results from ROAR-1, ROAR-2, ROAR-3, ROAR-4		B. Wahl	C
3	.04	.01	.05		Science Raft Test Stands (TS4-9)	This Control Account level of the WBS includes Efforts to design, engineer procure and assemble the test stations **TS1** through TS9 necessary for acceptance and characterization of the sensor, electronics and raft tower assemblies. Scope also includes development of a modified TS8 (TS8a) with in-situ metrology, requirements analysis and documentation. **Hardware Deliverables:** •(1) TS4 - Warm Metrology •(1) TS5 - Cold Metrology •(1) TS6 - RTM Assembly •(3) TS7 - RTM Cryostat •(2) TS8 - RTM Electro-Optical Testing •(1) TS8a - RTM Electro-Optical Testing with in-situ metrology (deliver to SLAC for Camera I&T) **Data Deliverables:** Test procedures, travelers, calibration certification, requirements and design documentation. 2014-11 PMB Start **BCR-002 #4 (CCS Test Stand Update)** **BCR-020 #3 (Science Sensor/Raft Updates)**		B. Wahl	C
3	.04	.01	.05	.01	RSA Assembly - Warm Metrology (TS4)	This Sub-Account WBS cell includes: The efforts to design, engineer, procure and assemble TS4. Scope also includes requirements analysis and documentation. **Hardware Deliverables:** (1) TS4 - Warm Metrology **Data Deliverables:** Test procedures, travelers, calibration certification, requirements and design documentation.		B. Wahl	S
3	.04	.01	.05	.02	RSA & RTM Cold Metrology (TS5)	This Sub-Account WBS cell includes: The efforts to design, engineer, procure and assemble TS5. Scope also includes requirements analysis and documentation. **Hardware Deliverables:** (1) **TS4** - Cold Metrology **Data Deliverables:** Test procedures, travelers, calibration certification, requirements and design documentation.		B. Wahl	S
3	.04	.01	.05	.03	RTM Assembly (TS6)	This Sub-Account WBS cell includes: The efforts to design, engineer, procure and assemble TS6. Scope also includes requirements analysis and documentation. **Hardware Deliverables:** (1) TS6 - RTM Assembly **Data Deliverables:** Test procedures, travelers, calibration certification, requirements and design documentation.		B. Wahl	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.04	.01	.05	.04	RTM Cryostat Integration (TS7)	This Sub-Account WBS cell includes: The efforts to design, engineer, procure and assemble TS7. Scope also includes requirements analysis and documentation. **Hardware Deliverables:** (1) TS7 - RTM Cryostat Integration **Data Deliverables:** Test procedures, travelers, calibration certification, requirements and design documentation.		B. Wahl	S
3	.04	.01	.05	.05	RTM Electro-Optical Testing (TS8)	This Sub-Account WBS cell includes: The efforts to design, engineer, procure and assemble TS8. Scope also includes requirements analysis and documentation. **Hardware Deliverables:** (2) TS8 - RTM Electro-Optical Testing **Data Deliverables:** Test procedures, travelers, calibration certification, requirements and design documentation.		B. Wahl	S
3	.04	.01	.05	.06	RTM Electro-Optical Testing (TS8a)	This Sub-Account WBS cell includes: The efforts to design, engineer, procure and assemble TS8a which includes in-situ metrology. Scope also includes requirements analysis and documentation. This Test Stand will be delivered to SLAC for Camera I&T. **Hardware Deliverables:** (1) TS8a - RTM Electro-Optical Testing (with in-situ metrology) **Data Deliverables:** Test procedures, travelers, calibration certification, requirements and design documentation.		B. Wahl	S
3	.04	.01	.05	.07	Mechanical Test Stand (TS9)	This Sub-Account WBS cell includes: The efforts to design, engineer, procure and assemble TS9. Scope also includes requirements analysis and documentation.TS9 will be used for Mechanical and thermal qualification of the RTM including the RSA. **Hardware Deliverables:** (1) TS9 - Mechanical Test Stand **Data Deliverables:** Test procedures, travelers, calibration certification, requirements and design documentation.		B. Wahl	S
3	.04	.01	.05	.08	RTM Handling Cart	This Sub-Account WBS cell includes: The efforts to develop a cart to handle and articulate the TS8 and TS5 dewars. Scope includes development and **analysis** of requirements, trade studies, and documentation. **Hardware Deliverables:** (2) RTM Handling Carts **Data Deliverables:** Design **compliance** validation.		B. Wahl	S
3	.04	.01	.06		Science Raft Production Assembly and Test	This Control Account level of the WBS includes: Effort assemble and test SRTM Engineering Test units and production SRTM's. Hardware Deliverables: (2) Engineering Test SRTM units (ETU's) (21) production SRTM units (1) spare SRTM unit Data Deliverables: QA reports, eTravler data, test data reports, raw image data. 2014-11 PMB Start **BCR-018 #1 (Science Raft Material)** **BCR-020 #3 (Science Sensor/Raft Updates)** **BCR-026 #1 (Mar16 Science Raft Integration Replan)** **BCR-026 #3 (Mar16 Science Raft ETU#1 Replan)** **BCR-040 #2 (SR Scope Changes, LCN-1715). Budget for (a) 10 RTM Shipping Containers, (b) baking equipment for RTM materials and (c) protective tooling for Sensors and RSAs.** **BCR-041 #1 (Sensor Replan)** **BCR-047 #2 (Feb17, Sensor V1 Award Update)** **BCR-049 #1 (Science Raft Enhanced Shipping). to use enhanced**		B. Wahl	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						shipping methods when shipping to SLAC. **BCR-057 #1 (E2v Sensor Replan)** **BCR-049 - Science Raft Enhanced Shipping to use enhanced shipping methods when shipping to SLAC.** **BCR-084 #2 - Reconstruction of Science Rafts** - To provide the necessary resources to re-construct 5 Science Rafts that are now known to have performance issues. • To provide the necessary resources to re-verify 4 Science Rafts that are now known to have performance issues and were returned to BNL for repairs. **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss			
3	.04	.01	.07		**Assembly and Test Assembly and Test Facility (BNL Cleanroom)**	This Control Account level of the WBS includes Effort to develop the cleanroom layout, operational plans, procedures, contamination and ESD compliance, commissioning, and operations. **Hardware Deliverables:** Operational Cleanroom **Data Deliverables:** Operation procedures 2014-11 PMB Start **BCR-002 #5 (SR & Sensor Updates)** **BCR-014 (September Admin Changes)** **BCR-020 #3 (Science Sensor/Raft Updates)** **BCR-026 #6 (Mar16 Administrative/Correction)**		B. Wahl	C
3	.04	.01	.07	.01	**Cleanroom Development & Commissioning**	This Sub-Account WBS cell includes: The efforts to set up infrastructure equipment, commission Test Stands 1-8, and general Cleanroom SOP. **Hardware Deliverables:** Infrastructure equipment (optical tables, work benches, storage cabinets, tools,) **Data Deliverables:** Operational procedures		B. Wahl	S
3	.04	.01	.07	.02	**Cleanroom Operations**	This Sub-Account WBS cell includes: The efforts procurement of consumables items, contracting services and space-charge. Scope also includes procurement of consumables, and contracted services. An LOE component is also included for a Cleanroom Coordinator, Manufacturing Engineer and Physicist. **Hardware Deliverables:** Consumables (ESD gowns, gloves, ...) **Data Deliverables:** None		B. Wahl	S
3	.04	.01	.07	.03	**ComCam and I&T Support**	This Sub-Account WBS cell includes: The efforts to support ComCam development and commissioning. **Hardware Deliverables:** None **Data Deliverables:** Analysis reports and procedures		B. Wahl	S
3	.04	.02			*Corner Raft System*	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the corner raft system. **BCR-062 - CAM change** from Vincent Riot to Sven Herrmann (3.04.02.01, 3.04.02.02, 3.04.02.03, 3.04.02.04 & 3.04.02.05)	LLNL	S. Herrmann	R
3	.04	.02	.01		**Corner Raft System Integration and Management**	This Control Account level of the WBS includes: The design integration and management costs for the corner rafts of the Camera. This includes the effort to complete the baseline budget and schedule, to manage the budget and schedule and to track and document the earned value. It also includes sub-system level system engineering, specifications and interface documentation. Travel is also covered by this element.	LLNL Harvard SLAC	S. Herrmann	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						Deliverables: Baseline budget and schedule, Sub-system wide requirements, Sub-System wide interfaces. 2014-11 PMB Start **BCR-034 #1 (CR New scope for TS-7 & TS-8)** **BCR-039 (LSST Camera Re-org)** **BCR-064 (PM and Sub-System CAM Re-Org**			
3	.04	.02	.02		Corner Raft Tower Module (CRTM)	This Control Account level of the WBS includes: Design, engineering, analysis, integration, procurement, fabrication, assembly, testing of the components comprising the corner raft tower, the tools required to assemble the corner raft tower into the cryostat, the development and characterization test-stands, and the tower shipping/storage containers Hardware Deliverables: 4 sets of assembled and tested corner raft tower components, including components assembled but not procured or fabricated in this WBS element (corner raft electronics cage is designed and fabricated in this WBS element, but electronics and raft sensor assembly is provided from sub-sequent WBS); 1 additional assembled and tested corner raft tower that can be used during integration. 1 set of tools required to assemble the corner raft tower into the cryostat. Data Deliverables: travelers and test reports for each CRTM (includes Electro-Optical testing test report); database, assembly/rework/handling procedure. Fixtures and Test Equipment: 5 shipping/storage containers, cold single CCD test-stand, cold raft EO test stand including chamber and EO test equipment. 2014-11 PMB Start **BCR-002 #1 (CR Elect Scope)** **BCR-016 #1 (Corner Raft Cold Test Stand Scope)** **BCR-028 #2 (New Scope, Cold Test-Stand Capability)** **BCR-034 #1 (CR New scope for TS-7 & TS-8). This BCR adds the new scope to build and commission a test stand 7 & 8. This scope was originally included in I&T and was called the SBEO test stand.** **BCR-039 (LSST Camera Re-org)** **BCR-071 #2 (Corner Raft Rephase)**	LLNL Harvard SLAC	S. Herrmann	C
3	.04	.02	.03		Corner Raft Sensor Assembly	This Control Account level of the WBS includes: Efforts to manage, design, engineer, procure, assemble, and test corner raft sensors and assembled corner raft sensor assemblies. 2014-11 PMB Start **BCR-005 (Wavefront Sensor Update)** **BCR-009 #3 (Apr-15 Baseline Updates)** **BCR-013 #4 (Sensor vendor update Scope)** **BCR-016 #1 (Corner Raft Cold Test Stand Scope)** **BCR-017 #2 (Vendor Award Update)** **BCR-022 #2 (Dec15 Wavefront Sensor Update)** **BCR-034 #1 (CR New scope for TS-7 & TS-8)** **BCR-036 #1 (Award of CR Baseplate Hardware)** **BCR-039 (LSST Camera Re-org)**	LLNL Harvard SLAC	S. Herrmann	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.04	.02	.03	.01	*Corner Raft Sensor Assembly (CRSA)*	This Sub-Account WBS cell includes: Efforts to manage, design, engineer, procure, and assemble corner raft sensor components, tooling fixtures, and integrated corner raft baseplates, resulting in complete corner raft sensor assemblies. This includes the thermal strap design between the CRSA and the CRTM. The element covers work required to install 2 guide sensors and one wavefront sensor onto corner raft baseplates; perform metrology on corner raft-sensor assemblies and adjust z-heights until all imaging surfaces meet z-height specifications; install temperature sensors, heaters, and thermal straps to corner raft baseplates; thermal-cycle CRSAs; perform cold metrology testing; analyze flatness data and produce reports; store assembled CRSAs in protective containers. **Hardware Deliverables:** 4 assembled and tested production CRSAs plus 1 ETU/first article CRSAs. **Data Deliverables:** travelers and test reports for each CRSA; database, assembly/rework/handling procedure. **Fixtures and Test Equipment:** assembly tooling, test stands; storage containers.	LLNL Harvard SLAC	S. Herrmann	S
3	.04	.02	.03	.02	*Wavefront Sensors*	This Sub-Account WBS cell includes: The management, design, engineering, analysis, integration, procurement, and testing verification of the wavefront CCD 2kx4k sensor devices **Hardware Deliverables:** 2 first article science grade devices, one engineering grade device, 2 fallout packaged mechanical grade devices and 14 science-grade sensor devices for the production CRTMs and engineering/first article CRTM. **Data Deliverables:** analysis software listing for verification and validation; travelers and test reports for each sensor handling procedures; pixel/amplifier layout diagram; operating procedures and limits.	Harvard	S. Herrmann	S
3	.04	.02	.03	.03	*Guide Sensors*	This Sub-Account WBS cell includes: The management, analysis, integration, and characterization testing of the guide CCD 4kx4k sensors and sensor package. Those sensors are provided under the science sensor procurement and procurement and acceptance testing is covered under WBS 3.03. **Hardware Deliverables:** 10 science-grade sensors for the production CRTMs and engineering unit/first article **Data Deliverables:** Guider readout mode specific characterization data and reports, software necessary to operate the CCDs in guider mode.	Harvard	S. Herrmann	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.04	.02	.04		**Corner Raft Electronics**	This Control Account level of the WBS includes: The design integration and management costs for the science rafts electronics. This includes the effort to complete the design, simulation, fabrication and testing of the integrated circuit needed to control and readout the CCDs. 2014-11 PMB Start **BCR-002 #1 (CR Elect Scope)** **BCR-016 #1 (Corner Raft Cold Test Stand Scope)** **BCR-034 #5 (CR new scope for electronics firmware)**	SLAC	S. Herrmann	C
3	.04	.02	.04	.01	*Wavefront Electronics Board (WEB)*	This Sub-Account WBS cell includes: Efforts to manage, design, engineer, prototype, procure, and assemble the corner raft wavefront electronics board. Each board is capable of controlling and reading out two 2kx4k wavefront sensor devices. The board takes the data from the two devices, uses the LSST integrated circuits (ASPIC) to interface to the sensors, digitizes the analog signals and send the data to the WDAQ. The board also receives commands and timing information from the data acquisition system. **Hardware Deliverables:** 10 assembled and tested production WEBs. Needs 20 ASPIC **Data Deliverables:** travelers and test reports for each WEB; database, assembly/rework/handling procedure. Test results from single slice and engineering unit. **Fixtures and Test Equipment:** test stands; single slice prototype; engineering unit PCB.	SLAC	S. Herrmann	S
3	.04	.02	.04	.02	*Guider Electronics Board (GEB)*	This Sub-Account WBS cell includes: Efforts to manage, design, engineer, prototype, procure, and assemble the corner raft wavefront electronics board. Each board is capable of controlling and reading out two 4kx4k guide sensor. The board takes the data from two CCDs, uses the LSST integrated circuits (ASPIC) to interface to the sensors, digitizes the analog signals and send the data to the GDAQ. The board also receives commands and timing information from the data acquisition system. Effort includes risk reduction intermediate board to evaluate methods to clock the CCDs **Hardware Deliverables:** 10 assembled and tested production GEBs. Needs 40 ASPIC **Data Deliverables:** travelers and test reports for each GEB; database, assembly/rework/handling procedure. Test results from single slice (using single slice from WEB WBS item), alternate CCD clocking single slice and engineering unit. **Fixtures and Test Equipment:** test stands; alternate clocking single slice prototype; engineering unit PCB.	SLAC	S. Herrmann	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.04	.02	.05		**Corner Raft Characterization Station**	This Control Account level of the WBS includes: Management, design, engineering, analysis, integration, procurement, fabrication, assembly, testing of the facility to characterize the corner raft wavefront and guide sensors at Harvard. **Hardware Deliverables:** 1 station to characterize sensors at Harvard. **Fixtures and test equipment:** various instrumentation equipment, lab space at Harvard.	SLAC Harvard	S. Herrmann	C
3	.05				*Optics*	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the Camera optics. **BCR-073 - CAM change** from Scott Winters to Justin Wolfe for (All 3.05 WBS Levels).	LLNL	J. Wolfe	R
3	.05	.01			**Optics Integration & Management**	This Control Account level of the WBS includes: The design integration and management costs for the optical elements of the Camera. This includes the effort to complete the baseline budget and schedule, to manage the budget and schedule and to track and document the earned value. Travel and supplies are also covered by this element. 2014-11 PMB Start **BCR-002 #2 (Optics Mgmt. resource correction)** **BCR-028 #5 (Award Update)** **BCR-036 #3 (Award of BBAR Coating and new scope per LCN-1680)** **BCR-087 #2 – Pending BCR Update**, additional scope for project support	LLNL	J. Wolfe	C
3	.05	.02			**Filter Assemblies**	This Control Account level of the WBS includes: The design and analysis of the filter support frame; prototype and test frame and dummy filter; finalize frame and filter design; fabricate and load test frames; assemble filters in frames and map filter coating with respect to interface fiducials; design, fabricate, and assemble dummy filters for Filter Exchange system testing and for mass-balancing the Camera during operation. Also included are procurement preparation, fabrication, assembly and installation coordination, vendor site inspections and laboratory equipment and supplies needed to test the hardware. Hardware Deliverables: 6 filters in support frames, which includes blank procurement, polishing, coating, metrology and photometry; the 6 filters will be g, r, i, z, and y band filters. 6 dummy filters; coating maps. Data Deliverables: Optical metrology and acceptance data, null test data. Transmission verification data. Lifting, handling, cleaning, and servicing procedures. 2014-11 PMB Start **BCR-002 #2 (Optics Mgmt. resource correction)** **BCR-006 #2 (L1_L2 award update for phase 2)** **BCR-019 #1 (Optics Labor Scope)** **BCR-028 #5 (Award Update)** **BCR-036 Item #3:** Adds new scope to support contract activities which include: Incoming inspection of substrates Dry-runs of loading activities	LLNL	J. Wolfe	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						Chamber loading for witness sample and lens runs Cleaning of substrates prior to coating Measurements of witness sample and lenses Surface Quality inspections Final packaging and cleaning **BCR-047 #1 (Feb17, Optics Vendor Contract Mod)** **BCR-049 #2 (Award update for Filter Frames)** **BCR-054 #1 (Optics Scope Increases).** Adds scope for sustaining engineering and shipping between vendors			
3	.05	.03			L1-L2 Assembly	This Control Account level of the WBS includes: The efforts required to design, analyze the L1-L2 assembly support ring, ring support struts, lens flexures; fabrication and assembly of L1-L2 support rings, struts, and flexures; test complete assembly with dummy lens and proof-test loads; optical lens L1 with AR coating; optical lens L2 with AR coating. This element covers the work to assemble lenses into support ring and run optical null tests; design, fabricate, and test transport box and lifting, handling, and support fixtures for L1-L2 assembly; design, assemble, and test lens cap and purge system for L1 lens. The work necessary to develop the AR coating is not contained in this WBS (See L3 assembly WBS) **Hardware Deliverables:** L1-L2 Assembly; AR Coated L1 lens mounted in assembly; AR Coated L2 lens mounted in assembly; L1 lens cap; L2 lens cover; **Data Deliverables:** Optical metrology and acceptance data, L1 and L2 null test data pre-coating and post coating (interferometer data and wavefront measurement data). Transmission verification data. Lifting, handling, cleaning, and servicing procedures. Mechanical alignment and metrology measurements (critical dimensions and features). As built model. **Fixtures and Test Equipment:** L1-L2 assembly transport container; L1-L2 support stand; L1-L2 rotation/lift fixture; Lens 1 and Lens 2 shipping container for transportation of lenses by themselves, small scale polymer-based stereo-lithography model of the L1-L2 assembly. 2014-11 PMB Start **BCR-002 #2 (Optics Mgmt. resource correction)** **BCR-002 #3 (Optics L1_L2 Design Scope)** **BCR-006 #2 (L1_L2 award update for phase 2)** **BCR-016 #5 (Ball Contract Update/Scope)** **BCR-019 #1 (Optics Labor Scope)** **BCR-030 #1 (L1_L2 Replan)** **BCR-036 #3 (Award of BBAR Coating and new scope per LCN-1680)** **BCR-039 (LSST Camera Re-org)** **BCR-043 #1 (L1_L2 Scope Update, LCN-1720).** L1 and L2 lens simulators, update requirements and verify bi-pod feet dowel pin hole size and location to support LCA-77, spare seals and filters to support L1-L2 reassembly on the summit. **BCR-060 #1 (Optics L2 MS Update)** **BCR-063 (Sep17 L1_L2 Scope Update).** Additional scope update to add resources to cover risk reduction effort for the L1-L2 shipping and T&H of the individual lenses to the coating vendor. **BCR-070 #3 (L1_L2 Lens Shipping Change).** New scope added for shipping container design updates & transportation loads.	LLNL	J. Wolfe	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.05	.04			**L3 Assembly**	This Control Account level of the WBS includes: The design, analysis, and prototyping of the L3 lens assembly, covering the effort necessary to load-test L3 prototype to failure; finalize L3 lens assembly design; fabricate and assemble L3 lens assembly, a flat-glass dummy assembly, and an aluminum blank; vacuum, pressure, load, and thermal test all assemblies; run optical null tests; design, fabricate, and test transport and storage boxes for L3 assembly. This element covers the prototyping and development of the BBAR coating used on all lenses. Hardware Deliverables: L3 lens assembly, flat-glass assembly, aluminum blank, transport container, storage box. Data Deliverables: Metrology and acceptance data, null test data. Transmission verification data. Lifting, handling, cleaning, and servicing procedures. Fixtures and Test Equipment: lifting fixture, transport container. 2014-11 PMB Start **BCR-011 #1 (L3 Assembly Award)** **BCR-019 #1 (Optics Labor Scope)** **BCR-020 #2 (BBAR coating contract with TSESO)** **BCR-028 #5 (Award Update)** **BCR-036 #3 (Award of BBAR Coating and new scope per LCN-1680)** **BCR-054 #1 (Optics Scope Increases). Adds additional vendor support as a risk mitigation.** **BCR-087 #1 –** Additional scope for L3 Vendor Contract Update	LLNL	J. Wolfe	C
3	.06				**Camera Body, Mechanisms, Cryostat**	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the Camera Body, Shutter, Cryostat, Utility Trunk.		M. Oriunno P. Kairst, A. Callen	R
3	*.06*	*.01*			*Camera Body*	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the Camera Body. **BCR-062 - CAM change** from Martin Nordby to Marco Oriunno for (3.06.01.01, 3.06.01.02, 3.06.02.01 & 3.06.02.02)		M. Oriunno	R
3	.06	.01	.01		**Camera Body Integration and Management**	This Control Account level of the WBS includes: Manage the Camera Body and Purge System development effort: complete baseline budget and schedule and update for CD reviews; track actuals and earned value; complete cost and technical status reporting; support Camera management as a subsystem manager; identify and manage hazards and risks within the subsystem Maintain subsystem spec's and ICD's: develop subsystem spec's and flowdown from higher level spec's; develop ICD's with other subsystems and update for design reviews; Test Plans: develop and improve on subsystem development plan and verification test plan; develop and maintain parts and materials lists, process lists, and procedure lists Travel: all travel for the subsystem; Supplies for the subsystem; This cell does NOT include any subsystem component integration; this is covered in Camera I&T 2014-11 PMB Start **BCR-039 (LSST Camera Re-org)** BCR-064 (PM and Sub-System CAM Re-Org)		M. Oriunno	C

Total Project Cost (TPC)									
LSST Camera WBS								**LCA-125**	

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.06	.01	.02		**Camera Body Development**	This Control Account level of the WBS includes: Conceptual, preliminary, and final design and analysis of the Camera housing, back flange, and purge system; includes static and dynamic analyses of Camera body structure and thermal and flow analyses of purge system; Design, develop, fabricate, and test purge system prototype and flow test stand Develop and complete test and operational plans for Camera Body and Purge System Fabricate, assemble, and test Camera body structure and purge system components; Design, analyze, fabricate, and test fixtures and test equipment; write test procedures; Run camera body load testing and purge system verification testing; practice maintenance and handling procedures Support fabrication, assembly, and testing and writing operations and maintenance procedures; Hardware Deliverables: Camera housing, back flange, shroud; component positioning h'ware; purge lines, manifolds, component connections; purge unit; purge temp sensors on components; instrumentation package; cable ways, patch panels; shutter cables. Data Deliverables: Inspection and NDT test data; proof/qual test results; leak/pressure/flow test results. Documentation: Operations, test, and maintenance procedures. Fixtures and Test Equipment: Camera lift fixture; front/back flange close-outs; pressure/proof load test equip; proof test frame; purge unit housing; purge system test set-up/equip. 2014-11 PMB Start **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-029 #1 (New Scope, Filter 3mm move)** **BCR-031 #2 (Addition of 2nd Back Flange Scope)** **BCR-039 (LSST Camera Re-org)** **BCR-040 #3 (CBM testing scope per LCN-1681)** Addition of scope (per **LCN-1681**) for Camera Body and Purge System for testing scope for the assembly of purge cabinets, allowing for additional development of operations procedures and to better characterize functionality. **BCR-054 #2 (AWARD of Back Flange Contract)** **BCR-056 #1 (Camera Housing Award and Scope Update)**		M. Oriunno	C
3	.06	.02			*Shutter*	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the Camera Shutter. **BCR-062 - CAM change** from Martin Nordby to Marco Oriunno for (3.06.01.01, 3.06.01.02, 3.06.02.01 & 3.06.02.02)		M. Oriunno	R

Total Project Cost (TPC)									
LSST Camera WBS								**LCA-125**	

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.06	.02	.01		**Shutter Integration and Management**	This Control Account level of the WBS includes: Manage the Shutter development effort: complete baseline budget and schedule and update for CD reviews; track actuals and earned value; complete cost and technical status reporting; support Camera management as a subsystem manager; identify and manage hazards and risks within the subsystem Maintain subsystem spec's and ICD's: develop subsystem spec's and flowdown from higher level spec's; develop ICD's with other subsystems and update for design reviews; Test plans: develop and improve on subsystem development plan and verification test plan; develop and maintain parts and materials lists, process lists, and procedure lists Travel: all travel for the subsystem; Supplies for the subsystem; This cell does NOT include any subsystem component integration; this is covered in Camera I&T 2014-11 PMB Start **BCR-039 (LSST Camera Re-org)** **BCR-064 (PM and Sub-System CAM Re-Org)**		M. Oriunno	C
3	.06	.02	.02		**Shutter**	This Control Account level of the WBS includes: Conceptual, preliminary, and final design and analysis of the Shutter mechanism; Design, develop, fabricate, and test shutter prototypes: actuator test bed; light-box and blade overlap simulators; drive system test bed; life-test prototype; light-tight/environmental test bed station Develop and complete test and operational plans; Fabricate and assemble shutter units; Design, fabricate, and assemble fixturing and test equipment; Run shutter unit verification and wear-in testing; practice maintenance and handling procedures Support fabrication, assembly, and testing of Shutter units and writing operations and maintenance procedures Hardware Deliverables: Shutter units (2x); replacement blade set; mount hardware; purge line fittings; cabling Data Deliverables: Inspection data; life test results; performance test results and timing characterization. Documentation: Operations, test, and servicing procedures. Fixtures and Test Equipment: Insertion/extraction rail; lift/transport fixture; servicing frame; transport container. 2014-11 PMB Start **BCR-017 #2 (Vendor Award Update)** **BCR-020 #1 (Shutter ETU Development)** **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-023 #6 (Feb15 I&T Replan)** **BCR-029 #1 (New Scope, Filter 3mm move)** **BCR-036 #4 (Shutter FDR Replan)** **BCR-039 (LSST Camera Re-org)** **BCR-072 #2 (Award of Shutter Blade Contract)**		M. Oriunno	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.06	.03			**Exchange System**	This WBS element summarizes the development, fabrication, and delivery the Filter Exchange System, including fixturing and lab equipment for storing and swapping out extra filters. It covers efforts to manage Exchange System development and fabrication; establish internal interfaces within group; develop overall design and operational requirements; complete overall analyses; complete preliminary operations plans; develop control system requirements; design, procure, assemble, and test exchange control system controller and interfaces; develop exchange system fixturing and test equipment; fabricate, assemble, and test fixturing; assemble exchange system sub-assemblies; develop and run system-level performance verification tests. **Hardware Deliverables:** Completed Filter Exchange System; 1 interchangeable Auto Changer. **Data Deliverables:** Sub-assembly inspection and test data; system-level performance test results; integrated operations, test, and servicing procedures. **Fixtures and Test Equipment:** 2 Filter Loader modules; filter storage and lab equipment; stand-alone controller unit for exchange system.	Multi (France)	P. Karst	R
3	.06	.03	.01		*Auto Changer*	This Sub-Account WBS cell includes: Work to develop, design and analyze the Auto Changer; prototype Auto Changer; fabricate and assembly parts; develop servicing/test plans; write operations procedures; run functional tests. **Hardware Deliverables:** 2 Auto Changer modules. **Data Deliverables:** inspection data; proof/qual test results; functional test results; operations, test, and servicing procedures. **Fixtures and Test Equipment:** Insertion rail system; assembly and servicing frame; dummy filters; stand-alone controller unit.	CPPM (Marseille)	P. Karst	S
3	.06	.03	.02		*Filter Loader*	This Sub-Account WBS cell includes: The effort required to develop the design of Filter Loader and lab support equipment; prototype Changer; fabricate and assemble Filter Loader and servicing equipment; develop servicing/test plans; write operations procedures; fabricate and assemble filter storage and loading equipment. **Hardware Deliverables:** 3 Filter Loader modules (no on-telescope hardware). **Data Deliverables:** Inspection data; proof/qual test results; functional test results; operations, test, and servicing procedures. **Fixtures and Test Equipment:** Filter storage cartridges; lab exchange stand; Filter Loader transport cart; stand-alone controller unit.	LPSC (Grenoble)	P. Karst	S
3	.06	.03	.03		*Carousel*	This Sub-Account WBS cell includes: The work required to manage Carousel development and fabrication; develop design and analyze Carousel; prototype Carousel assemblies and support exchange system prototyping; fabricate and assemble Carousel parts; develop servicing/test plans; write operations procedures; design, fabricate, and assemble fixturing for assembly and testing; assemble and test Carousel; run performance verification tests. **Hardware Deliverables:** 1 Carousel. **Data Deliverables:** inspection data; proof/qual test results; functional test results; operations, test, and servicing procedures. **Fixtures and Test Equipment:** stand-alone controller unit.	LPHNE (Paris)	P. Karst	S
3	.06	.04			*Cryostat*	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the Cryostat.	SLAC	T. Markiewicz	R

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.06	.04	.01		**Cryostat Integration & Management**	This Control Account level of the WBS includes: Work performed to manage cryostat subsystem development, fabrication, assembly and testing; travel and management support for subsystem; manage cryostat cost accounts; develop and maintain subsystem requirements and interfaces; flow down requirements to components; manage engineering development of the cryostat and work of scientists and engineers. **Hardware Deliverables:** NONE **Data Deliverables**: EVMS Data, Monthly Status Reports, Variance Reports, BCR's, ICD', IDD's Cryostat Specifications, Cryostat contribution to camera level requirements, specifications and interfaces. **Fixtures and Equipment:** NONE 2014-11 PMB Start **BCR-020 #4 (Cryostat Updates)** **BCR-039 (LSST Camera Re-org)** **BCR-048 (February 2017 Cryostat Refrigeration Replan)** **BCR-064 (PM and Sub-System CAM Re-Org)** **BCR-068 #3 (Cryostat Replan and Award Updates).** A lead engineer was added to assist in monitoring the completion of this sub-system. **BCR-075 (Standing Army Scope Updates)**	SLAC	T. Markiewicz	C
3	.06	.04	.02		**Cryostat Housing & Assembly**	This Control Account level of the WBS includes: The management, design, engineering, production, assembly and testing effort to produce the Cryostat Housing and the Assembly. 2014-11 PMB Start **BCR-009 #3 (Apr-15 Baseline Updates)** **BCR-018 #2 (CRYO assy/alignment)** **BCR-019 #3 (CRYO assy/alignment)** **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-034 #2 (Award updates)** **BCR-068 #3 (Cryostat Replan and Award Updates)**	SLAC	T. Markiewicz	C
3	.06	.04	.02	.01	**Cryostat Housing**	This Sub-Account WBS cell includes: Work performed to develop cryostat housing, internal support system and warm shroud designs and analyze per subsystem requirements; complete final design, manufacturing, inspection, NDT, and verification test plans; procure; manage manufacturing, assembly and inspection of the cryostat housing; **Hardware deliverables:** cryostat body (frustum weldment, end flanges, internal support features, mounts, ports for getter system) ; warm shroud plate; support cylinder; mounting hardware. **Data deliverables:** fabrication inspection and NDT reports; test reports (incl proof, pressure, vacuum leak); operating procedures. **Fixtures and Equipment:** NONE		T. Markiewicz	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.06	.04	.02	.02	**Cryostat Assembly**	This Sub-Account WBS cell includes: Work performed to develop cryostat overall design, assembly, and test plans; design and fabricate cryostat assembly and test fixtures and hardware; develop overall sub-system-level verification test plans; design and fabricate proof and pressure test hardware, procure instrumentation, set up and run qualification tests; contract for engineering review per ASME BPV-VIII req's; vacuum leak test; write test reports and operating procedure; integrate cryostat components; test cryostat assembly; integrate operations procedures into overall cryostat operations manual. **Hardware Deliverables:** Completed cryostat assembly with integrated utility trunk; ground system refrigeration and vacuum processing equipment. **Data Deliverables:** operations manual; assembly test and inspection reports. **Fixtures and Equipment:** Cryostat assembly / inspection stand; cryostat cart; vacuum test **can;** dummy L3 flange; utility trunk spreader bar.		T. Markiewicz	S
3	.06	.04	.03		**Cryo and Cold Plates**	This Control Account level of the WBS includes: Work required to develop design of cryo and cold plates, Cryo support flexures, cryo feedthrough assemblies and cryo shrouds; run thermal and structural analyses to demonstrate performance; spec heaters and temp sensors; prototype cryo plate flow and thermal design; prototype inlet/outlet weld connections and feedthrough performance; complete final design, manufacturing, inspection, NDT, and verification test plans; manage manufacturing, assembly, and inspection of assemblies; complete proof test, pressure/leak test and performance test on cryo-cold plate, feedthroughs and flexure supports; procure heaters and temp sensors; develop and procure performance test controllers; write test reports and operating procedures. **Hardware Deliverables:** cryo plate (incl heaters, temp sensors, cold straps, inlet/outlet lines); cryo shroud cylinder; cryo shroud plate and getter pump mounts; back-end cage assembly (pump chimneys, radiation shields, mounts); cryo plate flexures; cryogenic feedthroughs, cold plate (incl heaters, temp sensors, inlet/outlet lines); cold plate flexures, cryogenic feedthroughs. **Data Deliverables:** fabrication inspection and NDT reports; test reports (incl proof, pressure/leak), performance test reports, operating procedures. **Fixtures and Equipment:** Cryo and cold plate fab and assembly fixtures, feedthrough fab and weld alignment fixtures, test heater blocks; Test systems interface hardware. 2014-11 PMB Start **BCR-004 #1 (Cryo/cold plates updates)** **BCR-018 #2 (CRYO assy/alignment)** **BCR-019 #3 (CRYO assy/alignment)** **BCR-020 #4 (Cryostat Updates)** **BCR-021 #1,#2 (FY16 resource conversion)**	SLAC	T. Markiewicz	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.06	.04	.04		Grid Assembly	This Control Account level of the WBS includes: Work required to develop design of grid assembly; run thermal and structural analyses to demonstrate performance; spec heaters and temp sensors; prototype single-bay grid, partial grid, and flexures, and design and fab prototype test set-up; prototype ball nest fab and alignment method, and design and fab test set-up; complete design, manufacturing, inspection, NDT, and verification test plans of all components; manage manufacturing, assembly, and inspection of assembly; design and fab proof test hardware and procedures; procure heaters and temp sensors; assemble grid and measure/correct ball co-planarity; design and fab performance test set-up; write test reports and operating procedures. **Hardware Deliverables:** grid assembly (incl ball nests, heaters, temp sensors, cold strap attach hardware, raft cam attachment); flexures (incl mount hardware and Elec isolation parts); Additional grid long lead material; Cell mockup; CeSic test coupon. **Data Deliverables:** ball nest alignment procedure; fabrication inspection and NDT reports; proof test report; struc/thermal performance test report; operating procedures. **Fixtures and Equipment:** proof test fixture; performance verification test vacuum chamber and hardware. 2014-11 PMB Start **BCR-004 #2 (Grid assy updates)** **BCR-009 #1 (Cryostat Grid Procurement award)** **BCR-017 #1 (Grid Contract Update)** **BCR-018 #2 (CRYO assy/alignment)** **BCR-031 #1 (Sensor, Optics & Cryo Award/Contract Updates)**	SLAC	T. Markiewicz	C
3	.06	.04	.05		Cryostat Backend & Vacuum Systems	This Control Account level of the WBS includes: The management, design, engineering, production, assembly and testing effort to produce the Cryostat Backend & Vacuum Systems. 2014-11 PMB Start **BCR-009 #3 (Apr-15 Baseline Updates)** **BCR-020 #4 (Cryostat Updates)** **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-039 (LSST Camera Re-org)** **BCR-080 #2 (Cryostat Power Feedthrough)** **BCR-082 #1 (Cryostat REB Power Feedthrough Cable** - This change addresses additional scope for the Cryostat Backend and Vacuum System design and procurement. This scope is only for the fabrication, potting, and leak test of the custom PCB into a conflat flange. **BCR-082 #2 (Upgrade to Vacuum System Design)** - Initial pump-down of the "empty" cryostat delivered by the cryostat group (LCA-10616 Cryostat Assembly), showed that the ion pumps mounted to the Pump Plate Assembly were considerably under-powered to provide the pumping capacity needed to maintain the cryostat at a stable vacuum. Furthermore, additional testing showed that the gas load in the empty cryostat was considerably higher than hoped, and rough analysis showed that with the additional cables and RTMs installed, this would increase greatly. **BCR-084 #4- New Scope Vacuum PLC Changes** - This change captures necessary updates for the vacuum system control parameters and control logic. Changes include the following: 1) Modify permit condition for turning on/off ion pumps 2) Remove the PLC permit control on gate valve when the turbo pump is off 3) Change PLC permit to turn on turbo pump from using analog output	SLAC	T. Markiewicz	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						signal to using relay output signal 4) Change PLC permit to turn on turbo pump from 20 Torr (analog) to 10 Torr (relay) 5) Change CCS permit to turn on turbo pump from 10 Torr (digital) to 5 Torr (digital) 6) Add CCS control when foreline vacuum fails 7) Change condition to call turbo pump is running.			
3	.06	.04	.05	.01	Cryostat Back End	This Sub-Account WBS cell includes: Work required to develop design of back end flanges and spec feedthroughs, pumps, and vacuum/purge valving; run structural analysis of flanges on cryostat; finalize design, manufacturing and test plans; procure flanges, feedthroughs, vacuum, and purge hardware; develop hardware to test feedthroughs, test feedthroughs, assemble flanges; run vacuum/pressure tests; write test reports and operating procedures. **Hardware Deliverables**: feedthrough plate (incl plate, elec/optical feedthroughs, vac/cryo tubes, cable strain-reliefs); pump plate assembly (incl plate, turbo-pump, vacuum valves, purge valves, back-fill system, pressure-relief valve); pump and instrumentation controllers, pneumatic system, mounting hardware and O-rings/gaskets. **Data Deliverables:** vacuum/pressure test reports; operating procedures **Fixtures and Equipment**: NONE. BCR-080 #2 - New scope added to support the Cryostat to cover costs of assembling and testing power feedthroughs. **BCR-082 #1 - Cryostat REB Power Feedthrough Cable** **BCR-082 #2 Upgrade to Vacuum System Design**	SLAC	T. Markiewicz	S
3	.06	.04	.05	.02	Getter Pumps	This Sub-Account WBS cell includes: Work required to develop design of evaporative and non-evaporative getter pumps, support and containments, and re-gen system; design, fab, and test prototype pump system; complete design, manufacturing and test plans for pumps; manage manufacturing, assembly, assembly and commissioning of re-gen system; procure hardware for re-gen system and test set-up; design and fab performance test set-up; write test reports and operating procedures. **Hardware Deliverables: evaporable** charcoal system, getter pump cartridges; insertion and re-gen system (incl load-lock, auxiliary pump, ion gauges). **Data Deliverables:** vacuum test reports for each pump cartridge; re-gen system operating procedures. **Fixtures and Equipment:** Test and storage system (incl storage/transport cans, pump speed test apparatus, calibrated leak, etc.).	SLAC	T. Markiewicz	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.06	.04	.05	.03	**Vacuum Processing and Ground Support**	This Sub-Account WBS cell includes: Work required to develop Ground Cart purge, roughing and back-fill system, develop cryostat vacuum bakeout and processing system, finalize designs; procure, fabricate, and assemble systems; develop verification test plans, fab, and assemble; functionally test off-camera; write operations procedures. **Hardware Deliverables:** Complete purge-rough vacuum system, including off-Camera vacuum hardware; off-camera purge hardware (incl purge manifolds, valves, pump ports, pressure vessel, metering, temp sensors, re-heaters, power supplies and controllers), vacuum ground system hardware (incl roughing pump, gauges, controller), purge ground system (incl **insulated** purge flex lines to camera, meters, filters, sensors, flow-control valves, racks and consoles). Complete Cryostat hardware bake out and vacuum cleaning (plasma cleaning) system including bakeout oven, heaters, vacuum pumping and monitoring system and control and monitoring. **Data Deliverables:** verification test reports; operating procedures. **Fixtures and Equipment:** verification test system.	SLAC	T. Markie wicz	S
3	.06	.04	.06		**Refrigeration System**	This Control Account level of the WBS includes: Work required to develop cryo and cold refrigeration systems; develop, fabricate, and validate performance of prototype systems; finalize thermo, fluids, and controls design; spec operation, safety, and environmental plans; procure, fabricate, and assemble cryo refrig systems; manage procurement and develop verification test system and plans; fab and assemble verification test hardware; perform vacuum leak checks; run performance verification tests off-camera; conduct "unplugging test" activities to understand slow plugging over time; conduct cold system trade study, conduct hose endurance and compatibility testing; conduct oil transport and moisture parameters testing on the sub-scale; write operations procedures. Hardware Deliverables: 2 complete cryo systems and 2 complete cold systems, including on-camera hardware (incl valve box, inlet/outlet vac-insulated lines, re-heaters, drain/purge system, support chassis, shut-off valves); instrument and control system (incl thermal system controller, sensors, flow meters); ground system (incl flex line umbilical's; compressor/filter/intercooler systems, refrigerant plumbing and fill system, purge system, plumbing systems, sensors and flow meters, local operator's terminal, vacuum system for insulating vacuum on the camera, racks, consoles)+Heat Exchanger Can Vacuum System. Data Deliverables: verification test reports; operating procedures; safety and environmental compliance paperwork. Fixtures and Equipment: verification test system; leak tester for clean hardware and leak tester for dirty hardware. 2014-11 PMB Start **BCR-004 #3 (Scope increases for refrigeration)** **BCR-009 #2 (Refrigeration System Changes)** **BCR-012 (Cryostat Refrigeration System Scope)** **BCR-020 #4 (Cryostat Updates)** **BCR-039 (LSST Camera Re-org)** **BCR-048 (February 2017 Cryostat Refrigeration Replan).** This section was updated according to the CRYO replan. **BCR-068 #2 (Cryo Cold System).** Adds new scope needed to fabricate, test and support Cold System Performance Test. **BCR-068 #3 (Cryostat Replan and Award Updates).** The Heat Exchange System procurement was aligned with the new vendor plan. The Compressor modules update is a make or buy update.	SLAC	T. Markie wicz	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						BCR-075 (Standing Army Scope Updates) **BCR-084 #6 Activity Replan for IN2P3 Funding** - • This change addresses the shifting of budget for previously planned DOE funded activities. The intent is that these activities will be funded and performed with IN2P3 funding when those become available.			
3	.06	.04	.06	.01	**Refrigeration System - Pre IR2**	This Sub-Account WBS cell includes: The design, engineering, procurement, assembly, and testing effort to produce one cryo and cold refrigeration systems in preparation for integration with the cryostat subsystem in the IR2 cleanroom. **BCR-048 - This section was updated according to the "CRYO replan".**	SLAC	T. Markiewicz	S
3	.06	.04	.06	.02	**Refrigeration System - IR2**	This Sub-Account WBS cell includes: The design, engineering, integration, installation, processing, and testing of the cryo and cold refrigeration systems and long lines plumbing in the IR2 cleanroom. **BCR-048 - This section was updated according to the "CRYO replan".**	SLAC	T. Markiewicz	S
3	.06	.04	.06	.03	**Refrigeration System - Chile System**	This Sub-Account WBS cell includes: The design, engineering, procurement, assembly, and testing effort to produce one cryo and cold refrigeration systems for integration with the cryostat and utility trunk camera subsystems. **BCR-048 - This section was updated according to the "CRYO replan".**	SLAC	T. Markiewicz	S
3	.06	.05			**Utility Trunk**	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the Utility Trunk.	SLAC	T. Markiewicz	R
3	.06	.05	.01		**Utility Trunk Integration & Management**	This Control Account level of the WBS includes: Work required to manage Utility Trunk subsystem development, fabrication, assembly and testing; travel and management support for subsystem; manage Utility Trunk cost accounts; develop and maintain subsystem requirements and interfaces; flow down requirements to components; manage engineering development of the Utility Trunk and work of scientists and engineers. Hardware Deliverables: NONE Data Deliverables: EVMS Data, Monthly Status Reports, Variance Reports, BCR's, ICD', IDD's, UT Specifications, UT contribution to camera level requirements, specifications and interfaces. Fixtures and Equipment: NONE 2014-11 PMB Start **BCR-039 (LSST Camera Re-org)** **BCR-053 #1 (Utility Trunk Replan and Scope)** **BCR-064 (PM and Sub-System CAM Re-Org)**	SLAC	T. Markiewicz	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.06	.05	.02		**Utility Trunk Thermo-Mechanical and Assembly**	This Control Account level of the WBS includes: Work required to manage Utility Trunk subsystem development, fabrication, assembly and testing; travel and management support for subsystem; manage Utility Trunk cost accounts; develop and maintain subsystem requirements and interfaces; flow down requirements to components; manage engineering development of the Utility Trunk and work of scientists and engineers. Hardware Deliverables: NONE Data Deliverables: EVMS Data, Monthly Status Reports, Variance Reports, BCR's, ICD', IDD's, UT Specifications, UT contribution to camera level requirements, specifications and interfaces. Fixtures and Equipment: NONE 2014-11 PMB Start BCR-039 (LSST Camera Re-org) **BCR-053 #1 (Utility Trunk Replan and Scope)** **BCR-064 (PM and Sub-System CAM Re-Org)** **BCR-082 #2 - • Add small scroll pumps in the Utility Trunk** to serve as holding pumping to back the turbo-pumps in the cryostat and heat exchanger vacuums. Provide on-board power, CCS connectivity and commanding, and extend elements of the protection system to include these pumps. • Incorporate a pump/vent dry-down process for removing water vapor from hygroscopic materials in the cryostat volume, to reduce the overall time to pump down the cryostat. • Add band heaters and in-line N2 gas heaters, and modify the feedback control loops to allow the use of the cryo and cold plate trim heaters to run a low-temperature bake-out on the cryostat housing and its contents.	SLAC	T. Markiewicz	C
3	.07				**CCS, DAQ and Auxiliary Electronics**	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the Camera Control System, DAQ and Aux Electronics Camera subsystems.	APC SLAC	T. Johnson, M Huffer, G. Haller	R
3	.07	.01			**Camera Control System**	This WBS element summarizes the management, design, engineering, production, assembly and testing effort to produce the Camera Control System, which manages, monitors, and controls all Camera subsystem operations including sensor readout, motion actuation, temperatures, and the vacuum environment inside the cryostat. It includes infrastructure to monitor Camera operations and to detect, report and respond to errors.	APC SLAC	T. Johnson	R
3	.07	.01	.01		**Camera Control System Integration & Management**	This Control Account level of the WBS includes: The oversight of the design and production of the CCS as well as coordination of work with other LSST systems (observatory, telescope, and data management). Managers are responsible for making schedules and budgets, calling meetings, and monitoring progress toward the goals. This element covers use of the SLAC electronic traveler (eTraveler) system for camera test stands, construction and I&T. **Data Deliverables:** A dense set of milestones and associated reviews, with which progress can be assessed. Periodic reports of the status of CCS development. 2014-11 PMB Start **BCR-021 #1, #2 (FY16 resource conversion)** **BCR-049 #5 (CCS new travel scope to support IN2P3**) CCS Travel for FY18 is necessary to continue face-to-face CCS workshops with the IN2P3 partners in France.	APC SLAC	T. Johnson	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						BCR-061 #3 (Travel for UK collaborators to support CCS team). Additional travel budget for UK collaborators to travel to the US to attend workshops or pathfinder exercises. **BCR-087 #2 – Pending BCR Update**, additional scope for project supp**ort**			
3	.07	.01	.02		Camera Control System Core	The Control Account level of the WBS includes: Work required creating CCS infrastructure, which implements the core CCS functionality: infrastructure, master control logic, lock manager, database, code management, CCS Consoles, and diagnostic cluster. Hardware Deliverables: Core infrastructure hardware includes computers, which will live in racks in the summit computer room and at the base facility, as well as in the camera control room at the summit and base. Network hardware (e.g., cables and switches) and racks are not included. This includes database servers (at summit with mirror at base), servers for running MCM, OCS-CCS bridge, database interface, diagnostic cluster, visualization display, and consoles at summit and base. Software Deliverables: Core infrastructure software includes the operating system, compilers, software licenses, and other utilities that runs on the CCS infrastructure hardware and enables CCS operation. For code management, deliverable are an operational code repository (perhaps multiple instances), a standardized CCS compile-and-run environment, and a test suite for each Camera software component. Software modules that provide the required Master Control Module, locking management, logging, database management, image display, and monitor/alarm functionality. Software module to customize the existing IPAC (Caltech) developed display software for camera diagnostics use. 2014-11 PMB Start **BCR-009 #3 (Apr-15 Baseline Updates)** **BCR-010 (CCS Planning Pkg/I&T Link correction)** **BCR-013 #1 (CCS - Image Display Scope)** **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-036 #2 (New Scope per LCN-1662: CCS Supt, Rotator, I&T Displays).** Adds new scope to provide software to support display functionality and environment monitoring for I&T. This work includes interfacing CCS to the in-room and portable lighthouse units, writing a CCS subsystem to monitor and record the data from the units into the camera trending database, creating a monitoring GUI, including warning and alarm limits, and adding fixed displays in the I&T control room and outside the cleanroom door to allow cleanroom users to get rapid notice of any changes. **BCR-045 #1 (CCS Resource Change)** **BCR-082 #5 (Planning Package Updates)** **BCR-084 #6 Activity Replan for IN2P3 Funding** - This change addresses the shifting of budget for previously planned DOE funded activities. The intent is that these activities will be funded and performed with IN2P3 funding when those become available.	APC SLAC	T. Johnson	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.07	.01	.03		**Camera Control System HCUs**	This Control Account level of the WBS includes: The development and delivery of Hardware Control Units for each camera subsystem. Where appropriate this includes development of test stands for prototype testing, CCS support for I&T, and delivery of software for final camera HCUs. This element does include computer hardware to run HCU's for prototype test stands where needed, but not HCUs which will live in the camera utility trunk or on the camera itself (these are the responsibility of auxiliary electronics). Sensors, motors, and auxiliary electronics to connect these sensors to the subsystem are the responsibility of individual subsystems and/or auxiliary electronics. Hardware Deliverables: The I&T version of the diagnostic cluster and camera visualization system, and support for CCS console and fixed displays in the I&T control room. Computers for running prototype test stands where required. Camera Rotator This functionality is needed to support the CCS control of the Camera Rotator for I&T. This functionality is added due to the large number of rotator moves needed to complete camera assembly (earlier plans involved manual movement of the camera rotator). REB5/DAQ v1.1/PCI-PGP Additional scope is needed to adapt the CCS Rafts subsystem and TS8 subsystems to support an additional generation of electronics boards (REB5) and to support the full DAQ v1 functionality and readout speed as a result of the phased approach to development DAQ v1 feature set. Extra work is also involved in fully supporting DAQ v1 since we need to simultaneously maintain functionality for the PGP/PCI interface now used by some Corner Raft test stands. 2014-11 PMB Start **BCR-002 #4 (CCS Test Stand Update)** **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-011 #2 (Links CCS, DAQ and ScRaft)** **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-023 #6 (Feb15 I&T Replan)** **BCR-029 #2 (New Scope, CCS Integration Gantry)** **BCR-036 #2 (New Scope per LCN-1662: CCS Supt, Rotator, I&T Displays).** **BCR-045 #1 (CCS Resource Change)** **BCR-068 #1 (UT Quad Box).** Adds new scope to build and test a utility trunk quad box that can be used during I&T while the cryostat is being integrated on the Bench for Optical Testing (BOT) fixture. **BCR-068 #3 (Cryostat Replan and Award Updates)** **BCR-082 #2 Upgrade to Vacuum System Design** **BCR-084 #4 New Scope Vacuum PLC Changes**	APC SLAC	T. Johnson	C
3	.07	.02			**Data Acquisition System (DAQ)**	This WBS element summarizes the management, development design, engineering, production, assembly and testing effort to produce the DAQ system hardware and software.	SLAC	M. Huffer	R
3	.07	.02	.01		*DAQ Integration & Management*	This WBS element summarizes the management, development design, engineering, production, assembly and testing effort to produce the DAQ system hardware and software. **2014-11 PMB Start** • BCR-039 (LSST Camera Re-org)	SLAC	M. Huffer	C

Total Project Cost (TPC)									
LSST Camera WBS							**LCA-125**		
1	**2**	**3**	**4**	**5**	**WBS Name**	**Description**	**Institution**	**CAM**	**Type**
3	.07	.02	.02		*DAQ Hardware & Software*	This Control Account level of the WBS includes: The hardware and software design, engineering, production, assembly and testing effort to deliver the DAQ hardware and software. 2014-11 PMB Start **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-011 #2 (Links CCS, DAQ and ScRaft)** **BCR-013 #2 (DAQ - 3.1 version moved to 3.0)** **BCR-031 #3 (DAQ Replan)** **BCR-056 #2 (DAQ SATA Firmware)** **BCR-066 #2 (COB Hardware Components). Adds new components to the central hardware component of the Camera's DAQ System.** **BCR-068 #1 (UT Quad Box)** **BCR-070 #1 (DAQ Guiding Data System)** **BCR-081 #2 - Additional scope** added to fabricate, load and test three (3) new production candidate boards (V2).	SLAC	M. Huffer	C
3	.07	.02	.02	.01	*OpticalTransition Module (OTM) and Cabling*	This Sub-Account WBS cell includes: The development design, engineering, production, assembly and testing effort to produce the Optical Transition Module with associated cabling. **Hardware Deliverables:** OTM modules and associated cables **Software Deliverables:** N/A	SLAC	M. Huffer	S
3	.07	.02	.02	.02	*DAQ COB (Main ATCA DAQ Module)*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the COB main modules with associated daughter modules (DPM, DTM). **Hardware Deliverables:** COB, DPM, and DTM modules **Software Deliverables:** The firmware modules for the COB/DTM/DPM modules	SLAC	M. Huffer	S
3	.07	.02	.02	.03	*FPA/SSD-RTM (Rear Transition Module with IO-Links and Drives)*	This Sub-Account WBS cell includes: The development design, engineering, production, assembly and testing effort to produce the FPA/SSD Rear Transition Module for communication and storage. **Hardware Deliverables:** FPA/SSD RTM modules. **Software Deliverables:** The firmware modules for the FPGA components included in the RTM.	SLAC	M. Huffer	S
3	.07	.02	.02	.04	*DAQ FPA-RTM (Rear Transistion Module)*	This Sub-Account WBS cell includes: The development design, engineering, production, assembly and testing effort to produce the FPA Rear Transition Module for communication. **Hardware Deliverables:** FPA RTM modules. **Software Deliverables:** The firmware modules for the FPGA components included in the RTM.	SLAC	M. Huffer	S
3	.07	.02	.02	.05	*SSD-RTM (Rear Transistion Module, incl Drives)*	This Sub-Account WBS cell includes: The development design, engineering, production, assembly and testing effort to produce the SSD Rear Transition Module for data storage. **Hardware Deliverables:** SSD RTM modules. **Software Deliverables:** The firmware modules for the FPGA components included in the RTM.	SLAC	M. Huffer	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.07	.02	.02	.06	*ATCA Shelves*	This Sub-Account WBS cell includes: The purchase and testing effort to produce the ATCA shelves. **Hardware Deliverables:** ATCA shelves including shelf manager. **Software Deliverables:** N/A	SLAC	M. Huffer	S
3	.07	.02	.02	.07	*Source Communication Interface Firmware (SCI)*	This Sub-Account WBS cell includes: The development design, engineering and testing effort to produce the SCI firmware for the science raft board FPGA's. **Hardware Deliverables:** N/A **Software Deliverables:** Firmware for FPGA	SLAC	M. Huffer	S
3	.07	.02	.02	.08	*Crosstalk Correction Firmware*	This Sub-Account WBS cell includes: The development design, engineering and testing effort to produce the crosstalk correction firmware for the DAQ DPM FPGA's **Hardware Deliverables:** N/A **Software Deliverables:** Firmware for FPGA	SLAC	M. Huffer	S
3	.07	.02	.02	.09	*Raft Management/Data Server Software(RMS/RDS)*	This Sub-Account WBS cell includes: The development design, engineering and testing effort to produce the software for the raft management server and the data management server. **Hardware Deliverables:** N/A **Software Deliverables:** Software for RMS/RDS	SLAC	M. Huffer	S
3	.07	.02	.02	.10	*Timing Distribution Server Hardware and Software (TDS)*	This Sub-Account WBS cell includes: The development design, engineering, production, assembly and testing effort to produce the Timing Distribution Server. **Hardware Deliverables:** Timing Distribution Module for the RTM modules **Software Deliverables:** Software to incorporate the Timing Distribution Module	SLAC	M. Huffer	S
3	.07	.02	.02	.11	*FPA Emulation Server Software (FES)*	This Sub-Account WBS cell includes: The development design, engineering and testing effort to produce the software for the Focal Plane Array Emulation Server. **Hardware Deliverables:** N/A **Software Deliverables:** Software for FPA Emulation Server.	SLAC	M. Huffer	S
3	.07	.02	.02	.12	*Storage Array Software (SAS/SAC)*	This Sub-Account WBS cell includes: The development design, engineering and testing effort to produce the software for the storage array software. **Hardware Deliverables:** N/A **Software Deliverables:** Software for SAS/SAC BCR-056 - Added new scope for design, implementation and to test a device interface**.**	SLAC	M. Huffer	S
3	.07	.02	.02	.13	*DAQ Systems and Test Stands*	This Sub-Account WBS cell includes: The development design, engineering, production, assembly and testing effort to produce all the test stands for the sub-system efforts for the science raft testing (BNL, France), the corner raft testing (SLAC, Harvard), for I&T at SLAC, and for the Commissioning camera. This WBS also includes the full production DAQ system to be delivered to the camera. **Hardware Deliverables:** DAQ hardware for each test stand. **Software Deliverables:** Software installation and testing for each test stand.	SLAC	M. Huffer	S
3	.07	.02	.02	.14	*DAQ PGP*	This WBS is currently not in use	SLAC	M. Huffer	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.07	.02	.02	.15	*Guiding Data System (GDS)*	This Sub-Account WBS cell includes: The design, engineering, production, assembly and testing effort to produce a guiding data system. This system produced will meet the following requirements: • An API to characterize and communicate the ROIs acquired for each of the guiding sensors (software). • An API to wait on and receive the resulting ROI pixel data and its corresponding metadata (software). • An API to manage and control the start/stop and pause/resume ROI acquisition (software + firmware). • Mechanism to control and manage the necessary sequencing to produce ROIs (software). • Mechanism to reduce sensor images to their corresponding ROIs (software). • Mechanism to coordinate, trigger and time-tag ROI acquisition at 9 HZ (software). • Mechanism to transport arbitrary sized ROIs from RCE, over TPC/IP network to client software on commodity LINUX boxes (software). • An API to change from ROI mode to image mode for purposes of sensor calibration and test. **BCR-070 #1 - New WBS created** and scope added to project as noted above.	SLAC	M. Huffer	S
3	.07	.02	.02	.16	*Remote FPGA Reprogramming*	This Sub-Account WBS cell includes: Additional support in both the firmware and software of the DAQ system which would allow suitable, user-based "re-flashing" of the FPGA contained on any of the seventy-one (71) Raft-electronics Boards (REB), which in turn are contained within the twenty-five (25) camera rafts (independent of their respective type). To support this functionality requires additional functionality on all three, abstract levels of the DAQ system: • The SCI (Source-Communication-Interface) is the common firmware component on each FPGA of each REB. The SCI on one side communicates with its corresponding Sensor-Specific-Logic (SSL) while on its other side, through PGP to server-based code executing within an RCE (Reconfigurable-Cluster-Element). The envisioned changes are contained entirely within the SCI and affect neither the SCI/SSL API nor the SSL itself. • The RMS (Raft-Management-Service) Server is a software component executing an RCE. The server on one side communicates (through PGP) with the control and management functionality inherent in the SCI, while on the other side through a common network layer with its corresponding client-side code. In order to facilitate the earliest possible conclusion of the firmware effort an intermediate (throwaway) set of command line tools will be made available, so that the SCI changes can be tested without requiring either server or client functionality. • The RMS client is a software component executing on the user's host. The client on one side communicates (though the network) with its corresponding servers and on its other side presents a common API to client-based code. This API provides the user with all the necessary functionality to reprogram the FPGA remotely.	SLAC	M. Huffer	S
3	.07	.03			**Auxiliary Electronics**	This WBS element summarizes the development design, engineering, production, assembly and testing effort to produce the utility trunk cabling and crates, Camera protection, power control, raft thermal control, and control and monitoring modules.	SLAC	G. Haller	R

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						BCR-082 #2 – Upgrade to Vacuum System Design			
3	.07	.03	.01		*Aux Electronics Integration and Management*	This Control Account level of the WBS includes: The management effort and travel including overall system design for all the Auxiliary Electronics Hardware and Software. 2014-11 PMB Start **BCR-064 (PM and Sub-System CAM Re-Org)**	SLAC	G. Haller	C
3	.07	.03	.02		*Components*	This Control Account level of the WBS includes: The hardware and software design, engineering, production, assembly and testing effort to deliver the DAQ hardware and software. 2014-11 PMB Start **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-011 #2 (Links CCS, DAQ and ScRaft)** **BCR-013 #2 (DAQ - 3.1 version moved to 3.0)** **BCR-031 #3 (DAQ Replan)** **BCR-056 #2 (DAQ SATA Firmware)** **BCR-066 #2 (COB Hardware Components). Adds new components to the central hardware component of the Camera's DAQ System.** **BCR-068 #1 (UT Quad Box)** **BCR-070 #1 (DAQ Guiding Data System)** **BCR-081 #2 - Additional scope added to fabricate**, load and test three (3) new production candidate boards (V2). **BCR-082 #2 - • Add small scroll pumps** in the Utility Trunk to serve as holding pumping to back the turbo-pumps in the cryostat and heat exchanger vacuums. Provide on-board power, CCS connectivity and commanding, and extend elements of the protection system to include these pumps. • Incorporate a pump/vent dry-down process for removing water vapor from hygroscopic materials in the cryostat volume, to reduce the overall time to pump down the cryostat. • Add band heaters and in-line N2 gas heaters, and modify the feedback control loops to allow the use of the cryo and cold plate trim heaters to run a low-temperature bake-out on the cryostat housing and its contents.	SLAC	G. Haller	C
3	.07	.03	.02	.01	*AC and DC Power Distribution*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the AC and DC power distribution system including the breaker panel, the AC control and monitoring distribution chassis, the AC to various DC voltages conversion chassis, the raft power supplies, the HCU's for the various sub-systems, and the protection PLC system. Included are also the cables and networking for the Utility trunk. **Hardware Deliverables:** Breaker Panel, AC distribution chassis, AC to DC conversion chassis **Software Deliverables:** N/A	UofA	G. Haller	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.07	.03	.02	.02	*Custom Raft Supply Boards*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the custom raft supply boards. **Hardware Deliverables:** Power supply boards **Software Deliverables:** Firmware for control and monitoring of supplies, Ethernet IO, and power supply sequencing. **BCR-040 - Additional scope needed to fabricate, test and support Raft Power Supplies** for Science and corner raft test stands. Additional 5 supply sets have to be provided.	SLAC	G. Haller	S
3	.07	.03	.02	.05	*Custom Heater Power Supply and RTD Boards*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the heater power supply boards and for the temperature measuring boards. **Hardware Deliverables:** Power supply boards, temperature sensor monitoring boards **Software Deliverables:** Firmware for control and monitoring of supplies, and monitoring...	SLAC	G. Haller	S
3	.07	.03	.02	.07	*Custom DC Power Supply Chassis and Backplane*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the Power supply chassis and backplane... **Hardware Deliverables:** custom power supply chassis, conductive cooling. Backplane to hold the power supply boards. **Software Deliverables:** N/A	SLAC	G. Haller	S
3	.07	.03	.02	.09	*Shutter HCU Hardware*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the HCU for the shutter system... **Hardware Deliverables:** commercial HCU with custom sensor interface board. **Software Deliverables:** N/A	SLAC	G. Haller	S
3	.07	.03	.02	.10	*Camera body Purge HCU*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the HCU for the camera body system... **Hardware Deliverables:** commercial HCU with custom sensor interface board. **Software Deliverables:** N/A	SLAC	G. Haller	S
3	.07	.03	.02	.11	*Cryostat HCU*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the HCU for the cryostat system... **Hardware Deliverables:** commercial HCU with custom sensor interface board. **Software Deliverables:** N/A	SLAC	G. Haller	S
3	.07	.03	.02	.12	*Heater Ex, UT Cooling HCU*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the HCU for the heater exchange and UT cooling system... **Hardware Deliverables:** commercial HCU with custom sensor interface board. **Software Deliverables:** N/A	SLAC	G. Haller	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.07	.03	.02	.13	*Cables/Net working*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the cabling for the UT. Included are also networking i.e. switch. **Hardware Deliverables:** cables, network switch **Software Deliverables:** N/A	SLAC	G. Haller	S
3	.07	.03	.02	.14	*Protection PLC System*	The Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the protection PLC system **Hardware Deliverables:** commercial Programmable Logic Controller (PLC) with custom sensor interface board. **Software Deliverables:** N/A	SLAC	G. Haller	S
3	.07	.03	.02	.15	*Protection HCU System*	This Sub-Account WBS cell includes: The development, design, engineering, production, assembly and testing effort to produce the protection HCU system **Hardware Deliverables:** commercial HCU with custom sensor interface board. **Software Deliverables:** N/A	SLAC	G. Haller	S
3	.08			-	*Integration and Test*	This WBS element summarizes efforts to manage development and execution of Camera integration and test plans, including upgrading facilities and equipment at SLAC, designing and fabricating integration and test fixtures and equipment for cryostat and Camera integration. **BCR-055 - CAM change** from K. Reil to T.Bond for I&T WBS (3.08.01, 3.08.02, 3.08.03 & 3.08.04)	SLAC	K. Reil T. Bond	R
3	*.08*	.01			**I&T Integration & Management**	This Control Account level of the WBS includes: Effort required to manage I&T subsystem development and operation; travel and management support for subsystem including long-term travel to summit facility; manage I&T cost accounts; develop and maintain I&T requirements and interfaces; flow down requirements to components; manage interfaces to subsystems and summit facility; write I&T Plan, Verification Test Plan, and other documentation. Level of effort for managing and maintaining the IR2 facility and sustained engineering is also captured here. **Data Deliverables:** I&T requirements documents; ICD's with subsystems and LSST; I&T Plan; Verification Test Plan. 2014-11 PMB Start **BCR-002 #5 (SR & Sensor Updates)** **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-009 #3 (Apr-15 Baseline Updates)** **BCR-010 (CCS Planning Pkg/I&T Link correction)** **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-023 #6 (Feb15 I&T Replan)** **BCR-024 #3 (Feb16 Fixed Activity Duration)** **BCR-026 #4 (Mar16 Cryostat IRR Fix)** **BCR-034 #1 (CR New scope for TS-7 & TS-8)** **BCR-034 #3 (I&T new scope for SBMS)** **BCR-039 (LSST Camera Re-org)** **BCR-041 #1 (Sensor Replan)** **BCR-055 CAM change from K. Reil to T.Bond for I&T WBS (3.08.01, 3.08.02, 3.08.03 & 3.08.04)** **BCR-068 #3 (Cryostat Replan and Award Updates)** **BCR-075 (Standing Army Scope Updates)** **BCR-077 #1 (Add'l Scope for I&T)**	SLAC	T. Bond	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						BCR-080 #1 (I&T Scientific Intern Support). New scope added to support the I&T Scientific staff in the day to day clean room operations, with a Junior Physicist Intern. **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss			
3	.08	.02			Verification Test Systems	This Control Account level of the WBS includes: Effort required to develop the Camera verification plan, including subsystem and Camera verification tests; coordinate verification test plans and data with LSST verification plans; develop Camera verification test hardware and equipment; design, analyze, fabricate, and assemble verification test hardware; develop test plans; procure test equipment; design test validation method; procure test validation equipment; set up and run verification test equipment; run validation tests; write verification procedures; support Camera verification tests and process data; compile end-item data package for delivery. Hardware Deliverables: Camera verification optical bench. Data Deliverables: verification procedures; validation test report; Camera verification test data and report. Fixtures and Test Equipment: verification optical bench validation test hardware. 2014-11 PMB Start **BCR-002 #4 (CCS Test Stand Update)** **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-009 #3 (Apr-15 Baseline Updates)** **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-023 #6 (Feb15 I&T Replan)** **BCR-028 #3 (Descope, Single Bay Metrology Stand)** **BCR-033 #1 (Removal of Single Bay Electrical Optical (SBEO) from I&T)** **BCR-034 #3 (I&T new scope for SBMS)** **BCR-039 (LSST Camera Re-org)** **BCR-051 #2 (IR2 Pump/Leak Check Cart and MF06 for RAFT's)** **BCR-053 #2 (BOT Material Replan)** **BCR-055 - CAM change** from K. Revil to T.Bond for I&T WBS (3.08.01, 3.08.02, 3.08.03 & 3.08.04) **BCR-068 #1 (UT Quad Box).** Adds new scope to build and test a utility trunk quad box that can be used during I&T while the cryostat is being integrated on the Bench for Optical Testing (BOT) fixture. **BCR-070 #4 (Augmented I&T BOT and Gantry Testing).** Adds new scope necessary to complete integrated testing of the Integration Gantry (IG) and the Bench for Optical Testing (BOT). **BCR-072 #1 (ETU#1 REB Upgrade).** the change captures the scope of work necessary to switch the 3x REB-4 electronics boards currently in ETU#1 to REB-5 versions. **BCR-076 #1 (Add'l Scope for I&T).** The change captures the scope of work necessary to service the thermal cooling systems associated with Science Raft verification test stand - TS7.	SLAC	T. Bond	C
3	.08	.02	.01		Acceptance Test Systems	This Sub-Account WBS cell includes: Systems used to acceptance hardware for I&T. Hardware Deliverables: see below	SLAC	T. Bond	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.08	.02	.01	.01	Single Bay Metrology Systems	This Sub-Account WBS cell includes: The hardware required to accept and test the metrology (flatness) of RAFT tower modules when received at I&T. This hardware is also used by the Corner RAFT subsystem. Hardware Deliverables: metrology system capable of measuring RAFT flatness. Data Deliverables: Metrology data (x,y,z/z1/z2). **BCR-034 - this scope was removed from I&T on a prior BCR.** Initial plan was to move it to Corner Raft. The has shifted from that plan and has decided to put the scope back into I&T. The major change from the original scope to the new scope is that the I&T team will not re-design the test stand. Instead, they will use the already existing design from the science raft sub-system.	SLAC	T. Bond	S
3	.08	.02	.01	.02	Single Bay EO Tests	This Sub-Account WBS cell includes: The hardware required to electro-optically test RAFT tower modules when received at I&T. This hardware is also used by the Corner RAFT subsystem. **Hardware Deliverables:** Electro-optical test stand, single RAFT cryostat. **Data Deliverables**: RAFT telemetry, RAFT data, performance data. **BCR-033 - this change removed this scope from I&T and it is being moved to Corner Raft** (see BCR-034). The only remaining scope here is the original prelim design and ICD update that was completed in 2015. **BCR-051 - MF06 for RAFT's**	SLAC	T. Bond	S
3	.08	.02	.01	.03	Vacuum Qualification Tests	This Sub-Account WBS cell includes: The work needed to be done to ensure camera hardware (or hardware used on camera) meets vacuum requirements.	SLAC	T. Bond	S
3	.08	.02	.02		Cryostat Test Systems	This Sub-Account WBS cell includes: Test systems used during cryostat assembly and test. **Hardware Deliverables:** see below	SLAC	T. Bond	S
3	.08	.02	.02	.01	BOT Test	This Sub-Account WBS cell includes: BOT Test: **Hardware Deliverables:** BOT - optical spot projector on movable stages. **Data Deliverables:** read out by science or engineering rafts. **Fixtures and Equipment:** HCU, position readout.	SLAC	T. Bond	S
3	.08	.02	.02	.02	Test RAFT program	The Sub-Account WBS cell includes: Test Rafts: **Hardware Deliverables:** 8+ test rafts - 1+ corner test rafts, cryostat mockup. **Data Deliverables:** RAFT integration feedback.	SLAC	T. Bond	S
3	.08	.02	.03		Camera Test Systems	This Sub-Account WBS cell includes: Test systems used during camera assembly and test. **Hardware Deliverables:** see below	SLAC	T. Bond	S
3	.08	.02	.03	.01	CCOB Test (SLAC)	The Sub-Account WBS cell includes: CCOB Test: **Hardware Deliverables:** None, this is work to support French CCOB effort.	SLAC	T. Bond	S
3	.08	.02	.03	.02	CCOB Test (France)	Note: This is a foreign contribution deliverable and only tracked by I&T.		T. Bond	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.08	.03			Cryostat I&T	This Control Account level of the WBS includes: Efforts to develop cryostat integration and test plans; write all procedures and travelers; complete cryostat assembly drawings and in-process configuration drawings; develop requirements, design, analyze, fabricate, assemble, and test all cryostat integration and test stands, fixtures, test, and handling equipment; design, procure, assemble, and test electronic support equipment, vacuum pump station; prototype integration methods and run tests and pathfinder integration run-throughs; manage component I&T into the cryostat and metrology and testing; personnel and recurring costs during cryostat I&T; run receiving tests and integrate components in the cryostat; run metrology scans and performance verification tests; collect all data deliveries from subsystems and I&T travelers and test records. Hardware Deliverables: Completely integrated cryostat, tested at temperature. Data Deliverables: Cryostat integration and servicing procedures; completed travelers and end-item data packages for components in the cryostat and the fully-integrated cryostat; metrology scan results of detector plane and calibration data. Fixtures and Test Equipment: Cryostat integration stand, Test rafts, Raft Tower integration gantry, Science raft gantry interface frame, Corner raft gantry interface frame, RCC gantry interface frame; test electronic support equipment. 2014-11 PMB Start **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-009 #3 (Apr-15 Baseline Updates)** **BCR-010 (CCS Planning Pkg/I&T Link correction)** **BCR-021 #1,#2 (FY16 resource conversion)** **BCR-023 #6 (Feb15 I&T Replan)** **BCR-026 #4 (Mar16 Cryostat IRR Fix)** **BCR-029 #2 (New Scope, CCS Integration Gantry)** **BCR-034 #1 (CR New scope for TS-7 & TS-8)** **BCR-039 (LSST Camera Re-org)** **BCR-041 #1 (Sensor Replan)** **BCR-055 - CAM change from K. Revil to T.Bond for I&T WBS (3.08.01, 3.08.02, 3.08.03 & 3.08.04)** **BCR-068 #3 (Cryostat Replan and Award Updates)** **BCR-070 #4 (Augmented I&T BOT and Gantry Testing).** Adds new scope necessary to complete integrated testing of the Integration Gantry (IG) and the Bench for Optical Testing (BOT). **BCR-071 #2 (Corner Raft Rephase)** **BCR-075 (Standing Army Scope Updates)** **BCR-076 #1 (Add'l Scope for I&T).** The change captures the scope of work necessary to purchase the hardware (wires and connectors) and to fabricate the extra cabling needed to connect the finished Quad Box to the partially completed Cryostat while the testing is occurring in the BOT. **BCR-082 #2 Upgrade to Vacuum System Design** - • Add small scroll pumps in the Utility Trunk to serve as holding pumping to back the turbo-pumps in the cryostat and heat exchanger vacuums. Provide on-board power, CCS connectivity and commanding, and extend elements of the protection system to include these pumps. • Incorporate a pump/vent dry-down process for removing water vapor from hygroscopic materials in the cryostat volume, to reduce the overall time to pump down the cryostat. • Add band heaters and in-line N2 gas heaters, and modify the feedback control loops to allow the use of the cryo and cold plate trim	SLAC	T. Bond	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						heaters to run a low-temperature bake-out on the cryostat housing and its contents. **BCR-082 #3 SR Upgrade Support** – Lead Positioner - This change captures the additional scope necessary for the I&T Subsystem to support the Science Raft debugging/shipping activities by BNL staff at SLAC, as well as the activities to upgrade on-site Science Rafts with revised thermal straps and standoff feet as per determination by the Cryostat IRR review panel recommendations. • The changes in this BCR also captures the cost necessary for procurement of additional hardware necessary for augmentation to the Clean Room crane to allow more precise handling of critical Camera hardware within the clean room. **BCR-084 #2 Reconstruction of Science Rafts** - • To provide the necessary resources to re-construct 5 Science Rafts that are now known to have performance issues. • To provide the necessary resources to re-verify 4 Science Rafts that are now known to have performance issues and were returned to BNL for repairs. **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss **BCR-088 #1 – RTM1 Remediation & Reverification** • This change captures the new scope necessary to complete the repair and re-verification testing of the production Science Raft RTM1. The raft will be disassembled at SLAC and the RSA will be shipped to BNL where a single sensor will be replaced. The repaired RSA will be returned to SLAC where re-assembly of the RTM will take place. Finally, the SLAC I&T Staff will then perform a full reverification suite of tests on the raft in order to finalize its disposition. **BCR-089 – RTM11 Repair & Reverification** • This change captures the new scope necessary to complete the repair and re-verification testing of the production Science Raft RTM11. There appears to be an grounding issue between the REC walls and the radiation shields. The raft will be disassembled at SLAC and the thermal straps to the RSA will be removed and cleaned. The RSA will be re-assembled into the RTM and a final confirmation of proper grounding will take place. Finally, the SLAC I&T Staff will then perform a full reverification suite of tests on the raft in order to finalize its disposition.			
3	.08	.03	.01		**Integration Gantry**	This Sub-Account WBS cell includes: The design and fabrication of the primary "fixtures and test equipment" listed in 3.08.03. These fixtures are all those need to integrate RAFTs and corner RAFTs into the cryostat. These include the Cryostat integration stand, Raft Tower integration gantry, Science raft gantry interface frame, Corner raft gantry interface frame and RCC gantry interface frame.	SLAC	T. Bond	S
3	.08	.03	.02		**Cryostat Handling Equipment**	This Sub-Account WBS cell includes: The design and fabrication of the fixtures needed to move the cryostat between locations.	SLAC	T. Bond	S
3	.08	.03	.03		**Raft Acceptance Testing**	This Sub-Account WBS cell includes: The design and fabrication of the "fixtures and test equipment" needed to verify the RAFT integration fixtures. This includes a mechanical cryostat mock-up and "test rafts" as listed in 3.08.03.	SLAC	T. Bond	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.08	.03	.04		**Cryostat Assembly and Test**	This Sub-Account WBS cell includes: All of the actual integration and test work needed to integrate science and corner RAFTs into the cryostat and verification of requirements. Most of the 3.08.03 scope is captured here with the exception of the hardware mentioned in 3.08.03.01, 3.08.03.02 and 3.08.03.03.	SLAC	T. Bond	S
3	.08	.04			**Camera I&T**	This Control Account level of the WBS includes: Efforts to develop Camera integration, test, and calibration plans; write Camera I&T procedures and travelers; complete Camera assembly drawings and in-process configuration drawings; develop requirements, design, analyze, fabricate, assemble, and test all Camera I&T stands, fixtures, test, and handling equipment; write procedures for operating fixtures and train personnel; design, procure, assemble, and test electronic support equipment and test equipment for operating Camera components during integration; write operating procedures and train personnel; prototype integration methods and run tests and pathfinder integration run-throughs; includes personnel and recurring costs during I&T; run receiving tests, store, and integrate Camera components in the Camera; integrate components into utility trunk after delivery, and install and commission utility room components on skids for operation during I&T; collect all data deliveries from subsystems and I&T travelers and test records; manage I&T personnel; manage component I&T into the Camera and logistics; coordinate I&T activities. Hardware Deliverables: Fully integrated and tested Camera; 2 complete assemblies utilities systems on skids, tested and operating. Data Deliverables: Camera integration and servicing procedures; completed travelers and end-item data packages for Camera components and the fully integrated Camera. Fixtures and test equipment: Camera Integration Frame, Camera Integration Stand, Duplicate Rotator, Faro arm, Through-bore inspection stand, Forward-access inspection stand, Dummy changer flange, Camera housing proof test fixture, Camera housing proof test equip, Camera housing proof test weights, Back end cover plate, Test heaters, Filter simulator, Dummy filters, Filter changer proof test loads, Filter Loaders, Filter storage cartridges, Filter Loader docking station, Shutter installation rails, Dummy L2 lens region, L2 lens protector, Cryostat cart, Cryostat C-hook lifting fixture, Cryostat insertion guide rails, Front end cap, L1/L2 Ass'y line-of-sight test system, L1/L2 support frame, L1/L2 Assembly lift fixture. 2014-11 PMB Start **BCR-002 #5 (SR & Sensor Updates) BCR-006 #1 (Replan for work sequencing/resource allocation) BCR-021 #1,#2 (FY16 resource conversion) BCR-023 #6 (Feb15 I&T Replan) BCR-031 #2 (Addition of 2nd Back Flange Scope) BCR-036 #4 (Shutter FDR Replan) BCR-039 (LSST Camera Re-org) BCR-041 #1 (Sensor Replan) BCR-049 #3 (B33 and B660 security upgrade) BCR-051 #2 (IR2 Pump/Leak Check Cart and MF06 for RAFT's) BCR-055 - CAM change** from K. Revil to T.Bond for I&T WBS (3.08.01, 3.08.02, 3.08.03 & 3.08.04) **BCR-056 #1 (Camera Housing Award and Scope Update) BCR-068 #3 (Cryostat Replan and Award Updates) BCR-071 #1 (IR2 Services Upgrade BCR-075 (Standing Army Scope Updates) BCR-076 #1 (Add'l Scope for I&T).** The change captures the scope of		T. Bond	C

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						work necessary to provide additional secure, N2 flushed, Science Raft storage space needed in IR2 in order to accommodate the extra Science Rafts. **BCR-077 #4 (Replan of I&T Camera Handling Equipment). BCR-082 #3 SR Upgrade Support** – Load Positioner - • This change captures the additional scope necessary for the I&T Subsystem to support the Science Raft debugging/shipping activities by BNL staff at SLAC, as well as the activities to upgrade on-site Science Rafts with revised thermal straps and standoff feet as per determination by the Cryostat IRR review panel recommendations. • The changes in this BCR also captures the cost necessary for procurement of additional hardware necessary for augmentation to the Clean Room crane to allow more precise handling of critical Camera hardware within the clean room. **BCR-082 #4 Descope of Camera Saddle Stand** - • This change captures the removal of scope necessary to design, develop, fabricate, and test the Camera Saddle Stand from the I&T Subsystem. **BCR-086 – RTM Replan** – Addresses new scope necessary to repair and mitigate the channel/pixel loss			
3	.08	.04	.01		**Camera Integration Stand**	This Sub-Account WBS cell includes: The design and fabrication of the primary "fixtures and test equipment" listed in 3.08.04. These fixtures are the Camera Integration Frame, Camera Integration Stand and Duplicate Rotator (supplied by T&S).	SLAC	T. Bond	S
3	.08	.04	.02		**Camera Handling Equipment**	This Sub-Account WBS cell includes: The design and fabrication of the primary "fixtures and test equipment" listed in 3.08.04. These fixtures are the Camera Integration Frame, Camera Integration Stand and Duplicate Rotator (supplied by T&S). This Sub-Account WBS cell includes: The design and fabrication of the all the remaining "fixtures and test equipment" listed in 3.08.04. These include the through-bore inspection stand, Forward-access inspection stand, Dummy changer flange, Camera housing proof test fixture, Camera housing proof test equip, Camera housing proof test weights, Back end cover plate, Test heaters, Filter simulator, Dummy filters, Filter changer proof test loads, Filter Loaders, Filter storage cartridges, Filter Loader docking station, Shutter installation rails, Dummy L2 lens region, L2 lens protector, Cryostat cart, Cryostat C-hook lifting fixture, Cryostat insertion guide rails, Front end cap, L1/L2 Ass'y line-of-sight test system, L1/L2 support frame, L1/L2 Assembly lift fixture.	SLAC	T. Bond	S
3	.08	.04	.03		**IR2 Facility and Operations**	This Sub-Account WBS cell includes: The LSST clean room facility construction was moved off project. The remaining on-project work needed to finalize the LSST clean room facility is contained here. This includes N2 and air flow, IR2 networking, work benches, shelving, storage units, tools, tool boxes, optical tables. The full list of IR2 equipment is captured in the I&T basis of estimate (BOE). **BCR-049 - B33 and B660 security upgrade to improve the security of LSST Hardware in B33. BCR-051 - IR2 Pump/Leak Check Cart BCR-071 #1 - Scope added** for work necessary to perform the upgrades to IR2 (Water line for refrigeration and cryo plumbing, PCW	SLAC	T. Bond	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
						water lines to cleanroom, Install NEMA connector on Camera shut-off disconnect).			
3	.08	.04	.04		Camera Assembly and Test	This Sub-Account WBS cell includes: All of the actual integration and test work needed to integrate the camera and verification of requirements. Most of the 3.08.04 scope is captured here with the exception of the hardware mentioned in 3.08.04.01, 3.08.04.02 and 3.08.04.03.	SLAC	T. Bond	S
3	.08	.05			Transportation & Storage Equipment	This Control Account level of the WBS includes: The work needed to develop and review a shipping plan for the camera. **Hardware Deliverables:** None **Data Deliverables:** A shipping plan will be provided. **Fixtures and Test Equipment:** None 2014-11 PMB Start **BCR-023 #6 (Feb15 I&T Replan)** **BCR-039 (LSST Camera Re-org)** **BCR-056 #3 (I&T Full Camera Shipping Plan)** . Is to develop a full camera shipping plan. **BCR-069 #1 (Descope of Shipping Container).** This change captures the removal of scope for the shipping container from the LSST Camera project. The words above have been modified to reflect the change in scope.	SLAC	K. Reil	C
3	.08	.06			Commissioning Camera	This Control Account level of the WBS includes: The design, fabrication, assembly and testing of the MIE portions of the commissioning camera. Additionally, MIE funded LSST commissioning support is located in this control account. 2014-11 PMB Start **BCR-006 #1 (Replan for work sequencing/resource allocation)** **BCR-009 #3 (Apr-15 Baseline Updates)** **BCR-010 (CCS Planning Pkg/I&T Link correction)** **BCR-029 #2 (New Scope, CCS Integration Gantry)** **BCR-039 (LSST Camera Re-org)** **BCR-046 (February 2017 ComCam Replan)** **BCR-059 #1 (Transition to Ops Planning)** **BCR-068 #3 (Cryostat Replan and Award Updates)** **BCR-069 #2 (Descope of Commissioning Baseline Planning)**	SLAC	K. Reil	C
3	.08	.06	.01		Commissioning Camera Hardware	This Sub-Account WBS cell includes: The ComCam hardware provided by the MIE project is captured in this sub-account. Shipping, support in Tucson and all summit work is part of the LSST commissioning effort and not included in this scope. The commissioning camera is the based on Science Raft Test Stand 7 design. **Hardware Deliverables**: A functional imager consisting of 1) an engineering test RAFT (nominally ETU2), 2) cryostat, 3) cooling system and 4) vacuum system. All associated utilities including power systems, networking, etc (see LSE-199) that go in the utility thermal enclosure (enclosure supplied by MREFC). Also included are a DAQ system. **Data Deliverables:** Transport and handling procedures for use by Camera personnel and shippers; shipping instrumentation data reports. Import/export paperwork will be supported by MREFC. **Fixtures and Test Equipment:** Shipping containers and instrumentation for Commissioning Camera (MIE portions), support equipment, and ground facility hardware; rigging and handling equipment.	SLAC	K. Reil	S

1	2	3	4	5	WBS Name	Description	Institution	CAM	Type
3	.08	.06	.02		**CCS Commissioning Camera Tucson Hardware**	This Sub-Account WBS cell includes: CCS development and HCUs for the MREFC delivered shutter and filter changer are included in this sub-account. All scope in this subaccount was moved here from the prior master account (3.08.06) in BCR-059.	SLAC	K. Reil	S
3	.08	.06	.03		**CCS Commissioning Camera MIE Hardware**	This Sub-Account WBS cell includes: CCS development and HCUs for the MIE delivered cryostat, RAFT, utilities and MCM are included in this sub-account. All scope in this sub-account was moved here from the prior master account (3.08.06) in BCR-059.	SLAC	K. Reil	S
3	.08	.06	.04		**CCS Pathfinder**	This Sub-Account WBS cell includes: The MIE funding for CCS to participate in 5 software pathfinder activities between CCS, DAQ and MREFC funded TCS, OCS and DM. Added in BCR-059**.	SLAC	K. Reil	S
3	.08	.06	.05		**DAQ Pathfinder**	This Sub-Account WBS cell includes: The MIE funding for DAQ to participate in 5 software pathfinder activities between CCS, DAQ and MREFC funded TCS, OCS and DM. Added in BCR-059**.	SLAC	K. Reil	S
3	.08	.06	.06		**Commissioning Baseline Planning**	This Sub-Account WBS cell includes: Effort for the MIE camera project to develop a plan for transition to operations. Added in BCR-059.	SLAC	K. Reil	S