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CLOSEOUT REPORT of the Department of Energy/National Science Foundation Review Committee for the

Dark Energy Survey (DES) Project

Stephen Tkaczyk, Chair

DOE/SC Review Committee

September 10, 2008

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U.S. Department of Energy

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Review Committee Participants

Stephen Tkaczyk, DOE/SC, Chair

Review Committee

Subcommittee 1
Kem Robinson, LBNL*
Mark Reichanadter, SLAC

Subcommittee 2
Roger Smith, CalTech*
Alex Grillo, UCSC

Subcommittee 3
Matt Johns, Carnegie Inst.*
Ian Dell'antonio, Brown

Subcommittee 4
Robert Lupton, Princeton*
Rob Cameron, SLAC

* Lead

Observers

Mike Procario, DOE/SC
Kathy Turner, DOE/SC
Paul Philp, DOE/CH
Nigel Sharp, NSF

Charge Memorandum

1. Technical: Is the final design sufficiently mature so that the project can initiate procurement and fabrication? For those elements that are not finalized, has the project convincingly shown that there are no major issues that need to be addressed and that they have a clear path forward toward final design?
2. Baseline Cost and Schedule: Are the current project cost and schedule projections consistent with the approved baseline? Are the allocations of contingency adequate for the risks?
3. Management: Is the management structure adequate to deliver the proposed final design within specification, budget and schedule? Has the project responded satisfactorily to recommendations from the previous review?
4. Fabrication: Has there been adequate progress on the fabrication activities approved under CD-3a? Is the project satisfactorily prepared to execute the remaining fabrication activities?
5. Documentation: Is the DECam documentation required by DOE O 413.3A for CD-3b complete? Have the CD-2 documents been updated to reflect any changes resulting from the final design?

Report Outline/Writing Assignments

Executive Summary ..... Tkaczyk

1. Introduction ..... Turner
2. Technical
   - 2.1 DECam
     - 2.1.1 DECam Optics and Opti-Mech, CFIP ..... Johns*/Dell'antonio (SC3)
     - 2.1.2 DECam CCDs, SISPI, Electronics ..... Smith*/ Grillo (SC2)
   - 2.2 DESDM, Simulations, Calibration ..... Lupton*/Cameron (SC4)
3. Cost (DECam, DESDM, CFIP)…….. ..... Reichanadter*/Robinson (SC1)
4. Schedule and Funding (DECam, DESDM, CFIP)..... Reichanadter*/Robinson (SC1)
5. Management..... Robinson* (SC1)

* Lead
SC Subcommittee

2.1.1 DECam Optics & Opto-Mech, CFIP

- Matt Johns
- Ian Dell'antonio

2.1.1 DECam Optics & Opto-Mech, CFIP
M. Johns, I. Dell'antonio

Findings & comments:

- **The top-level specifications and technical requirements have been developed.** Flow-down requirements in the form of Requirement Specification Documents (RSDs) have been produced for nearly all of the major subsystems.

- **The DECam team has adequately addressed the recommendations from the January review leading up to CD2**.

- **Production of the DECam lenses is well underway**. Generated blanks for elements C1-C5 have been received retiring this source of risk. A contract has been issued to SESO for the polishing & coating of the lenses. A prototype cell is also under development.

- **A design study of the hexapod assembly including prototyping of an actuator is underway.** Results will be known around the end of the year. The hexapod assembly was an area for concern at the January review.

2.1.1 DECam Optics & Opto-Mech, CFIP
M. Johns, I. Dell'antonio

Findings & comments:

- **An finite element analysis of the upper Blanco structure was performed to demonstrate acceptable modal performance of DECam in the telescope and determine stiffness requirements for the hexapod actuators.** The lowest (local) modal frequency of DECam supported by its hexapod positioner to the (grounded) top ring assembly is 35 Hz. This is well above characteristic frequencies for turbulent wind disturbance.

- **An FE analysis of the barrel assembly indicates the assembly is sufficiently rigid.** Further analysis of lens cells and focal plane deflections is planned.

- **Thermal analysis of the heat given off by the DECam assembly ("the plume") indicates that the seeing will not be materially degraded for surface temperature differentials up to 3 degrees from ambient.** This specification currently being used in designing the camera assembly.

2.1.1 DECam Optics & Opto-Mech, CFIP
M. Johns, I. Dell'antonio

Findings & comments:

- **The DECam optics will be tested as a system only after assembly at CTIO and installation on the Blanco telescope.** Fabrication errors in the lenses (surface figure, center thickness, etc.) or coatings uncovered at this stage could have serious performance, schedule, and/or cost ramifications. The project should monitor this effort closely. Independent methods for testing the lenses and coatings to mitigate the risk are potentially available to the project.

- **The DECam filters are particularly challenging for potential suppliers.** The original transmission specifications were too stringent to be commercially feasible. Specifications have been relaxed and another round of procurement is underway. The project should monitor this effort closely and independently verify that the delivered filters meet specifications and consider the implications of higher order spatial variations in the filter transmissions. The lack of spares is a risk.

- **A prototype of the LN2 cooling system is being assembled.** The prototype will be tested on the Telescope Simulator with the MCCDTV imager prototype in the near future.

2.1.1 DECam Optics & Opto-Mech, CFIP
M. Johns, I. Dell'antonio

Findings & comments:

- **The prototype filter changer mechanism is nearing completion.** This allows ample time for reliability testing prior to shipment to CTIO.

- **No changes to the shutter design were presented.** This item should be purchased in time to allow off-telescope reliability testing under representative conditions.

- **The mechanism for mounting/removing the F/8 secondary mirror is a major improvement over the concept presented in January.** The current design addresses operational and safety concerns with the previous design.

- **The DECam project has a well defined cost and schedule and appears to be adhering to these**. Project management procedures have been tightened up. Risks are being tracked.

- **Designs for the major optical and opto-mechanical subsystems are sufficiently well advanced to proceed to CD3b.**

2.1.1 DECam Optics & Opto-Mech, CFIP
M. Johns, I. Dell'antonio

Findings & comments:

- **Plans for integration and installation of DECam and the optics at the Blanco are being developed.**

- **The CFIP projects are all progressing appropriately**. The projects have detailed, milestone-rich schedules and are all scheduled to complete at least 12 months before the arrival of DECam in Chile.

- **The CFIP projects that are critical to DECam's success are being given high priority to protect them from budgetary pressures.**

- **The TCS upgrade project is underway, and the scheduled completion date has moved forward three months, further reducing risk to DECam.**

- **The radial support H-bars are being machined at CTIO**. Installation is planned for spring 2009 during a 4-week shutdown. This project appears well-underway, but there is some concern that the spacing of the 24 supports needs to be very precisely controlled to prevent lateral shears on the new H-bars.

2.1.1 DECam Optics & Opto-Mech, CFIP
M. Johns, I. Dell'antonio

Recommendations:

1. **Conduct independent measurements of the DECam lens low-order surface figure and thickness during production to reduce program risk.** This could be accomplished using separate metrology (test plates?) provided by the supplier in tests witnessed by the project. Scrutinize the primary tests closely.

2. **Measure the transmission curves for the lens AR coatings (using witness samples) and filter functions to verify compliance with specifications.** U. Michigan is building test equipment to make these measurements.

3. **Complete the design study of the hexapod system and prototyping of an actuator prior to procuring the full system.** Verify the prototype meets the positioning and stiffness specifications.

4. **Proceed immediately to CD3b.**

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CCDs, FEE, SISPI

Alex Grillo
Roger Smith

CCD Findings

- As recommended from the Jan-08 review (granting of CD3A), production has started.
- CCD production, test, and focal plane integration infrastructure is in place along with plans to gain early experience integrating both hardware and software.
- By the end of FY08, roughly 40% of wafer production will be complete.

CCDs -- yield

Comments:

- 27% wafer probe yield-to-date is encouraging. (This is for wafers, not yet packaged devices.)
- The claim that stddev=6% is misleading when some lots have been total failures and others yielded from 5 to 29 devices.

Recomendations:

- Maintain efforts to keep CCD production running smoothly (not limited by funding) to produce CCDs early.
- Retain full contingency for extra CCD lots.

CCDs -- fabrication risk

Finding/Comment

- LBL's sputtering machine which is used for frontside metal and backside ITO and SiO_2 coatings was old when purchased in 1993 (uses tubes) and has caused production to stall for 25 weeks in last few years.
- We are concerned that a new sputtering machine ($400K) needs to be on hand and tested prior to the next failure of the current machine.
- Testing of a new machine needs to be done on non-DECam CCD wafers prior to next failure.

CCDs -- blooming levels

Comment:

- Crosstalk can only be corrected if the signal in the source pixels is known (ie does not saturate ADC.)

Recommendation:

- Standardized electronic gains then adjust clock rails for similar blooming level on all CCDs, falling just below ADC saturation.

FEE -- Findings

- All recommendations from the Jan-08 review have been addressed.
- Very good progress on finalizing design of readout electronics.
- With the exception of one board, the MCB being laid out in Spain, all pre-production versions are now being tested.
- These are expected to be final versions unless new issues arise during system testing.
- As recommended in the Jan-08 review, a visit was made to CTIO to investigate the present state of grounding. This proved to be very fruitful confirming the soundness of the initial scheme for DECam but also indicating more work is needed at CTIO to resolve present grounding issues.
- The plans for integration tests in Oct-08 through Feb-09 are very impressive and should do much to ring out both hardware and software issues.
- Not much in the way of performance data was shown nor was there a list of what changes to design had been made from earlier versions. This would have been helpful to the reviewers to see.

FEE - Recommendations

- Include ADC DNL in standard test suite
  - >100 Msample histogram of triangle wave
  - Implement single slope integration mode (non-CDS).
- Implement “No slope” mode for isolating output noise (integrator, ADC) from input noise (CCD, preamp).
- Inhibit LEDs prior to commissioning.

SISPI -- Findings

- Good progress has been made on software development since the Jan-08 review.
- A detailed milestone list with a high level of granularity has been created to closely monitor software development. This should facilitate project tracking, which is always difficult for software development, and will hopefully avoid schedule slips going unseen until late in the project.
- Plan to use real SISPI software in its present state of development for the hardware integration tests starting in October is an excellent idea which will be very useful to shake out software in a timely fashion.

SISPI -- comments

- Most SISPI software is funded separately from project, so…
- We are concerned about security of ongoing budgetary support for this vital component of DECam.

SISPI -- Recommendation

- Develop execution time requirements for all SISPI software. Notable requirements:
  - System should be ready to begin next exposure as soon as CCD readout clocking ends.
  - DECam startup from cold should take less than ~CCD readout time.
  - Minimize Linux reboot time, where possible.
- Make execution and communication timing part of standard software testing…. *from outset.*

2.2 DES Data Management

- Robert Lupton
- Rob Cameron

2.2 DES Data Management - Findings (1)

- DESDM has made significant progress since the January 2008 review.
- The DESDM project has expanded its WBS to include a science codes element; currently primarily addressing the lensing pipeline.
- The DESDM team has augmented its staff since the February review in response to recommendations. Staff were added at UIUC and FNAL.
- Some key areas of expertise still reside with individual team members; e.g. database expertise and support for science codes.
- Preparations for DC4 are well underway, and readiness for DC4 is generally high for all of the WBS elements.
- Some unit level testing and unit level regression testing has been put in place for several of the WBS development areas.
- The project has implemented some standard software practices (e.g. using svn and JIRA), but these practices are not yet widely employed

2.2 DES Data Management - Findings (2)

- Data simulations have progressed well, now including more realistic image artifacts. The strategy of using ever-more sophisticated simulations in conjunction with the Blanco Cosmology Survey (BCS) data to test DESDM is a sound one.
- Data Challenges to date have not significantly involved the science working groups. Stress testing of the system by the SWGs is currently only planned for the end of the development phase.
- Risk management is not in place, beyond identification of software development priorities as a contingency planning model.

2.2 DES Data Management - Comments (1)

- The DESDM team has made progress in estimating the level of effort required. We note that this is a difficult-to-impossible task, as individual's software talent and skills vary enormously.
- Core data reduction steps (e.g. transient detection) have been brought under DESDM's aegis, but the new steps are as yet very loosely coupled. The needed degree of integration with the DM infrastructure and codes is not yet clearly articulated.
- Hardware purchases have been deferred in lieu of supporting additional staff. NSF is expecting and is prepared for a request for supplemental funding.
- DESDM has un-funded contingency for which they intend to apply to NSF, but there is no other contingency in the budget

2.2 DES Data Management - Comments (2)

- The DESDM is being managed by 20% of an FTE. This probably needs to be increased
- Difference processing might be applied to general catalog data; but no plans for allowing such processing are in place.
- The scope of user (DES scientist and general public) access to the DES database is not clear to the reviewers.
- In the February 2008 review, it was stated that all goals were (eventually) met for DC3. But in the plenary session DESDM presentation, 2 DC3 objectives were listed as not met. It was not clear if these goals will be addressed in DC4; in general, it is not clear how stably the goals of each Data Challenge are a priori defined.
- There was no time to review the developments in the Data Access Framework, QA/QC, and the Community Pipeline during the DESDM splinter session. These should be reviewed at the next review.

2.2 DES Data Management - Recommendations (1)

1. Define the scope of, and requirements on, the science-ready data products. These requirements should be derived from the top-level science requirements, and tracked down to DESDM WBS tasks.
2. Ensure that all science collaborations (including those which are just forming now) have included their requirements in this effort.
3. In descriptions of data challenges, make it clear which of these requirements have been addressed, and the extent to which they have been met.
4. Classify principal risks in severity/likelihood matrix and track them as part of the DES project risk management system.
5. Use Data Challenges, starting with DC4, to produce realistic estimates of processing hardware requirements for the required throughput.

2.2 DES Data Management - Recommendations (2)

6. Increase the amount of effort applied to project management.
7. Continue to adopt and embrace standard software practices. In particular, show progress towards consistently using version tracking and bug-tracking systems by the next review.
8. Define the scope of the public and collaboration interfaces to the DES database.
9. Involve science working groups in data challenges, for example by using blind data challenge and requiring science groups to attempt to discover simulated science phenomena.

DOE/NSF Review of the Dark Energy Survey (DES) Project

Cost, Schedule and Funding

Mark Reichanadter, SLAC
Kem Robinson, LBNL

Cost Estimate - Findings

- DECam –
  - TPC is $35.2M:
    - R&D ~$11.7M
    - MIE ~$23.45M
  - All estimated costs are in $FY07, fully-burdened and include out-year escalation.
  - Installation/commissioning are not included in project.
  - Reporting earned-value since August 2007:
    - R&D 87% complete, Contingency on R&D $.28M (19% on cost to go)
    - MIE 3% complete, Contingency on MIE $6.78M (41% on cost to go)
  - CD-3b initiates construction on ~$2.2M critical components:
    - CCDs, shutters, filters, alignment fixtures, etc.

Cost Estimate - Findings

- DESDM -
  - The DESDM team presented its cost estimate in terms of FTE months:
    - D&D Phase (Complete) ~141.5 FTE months
    - Construction Phase (Jul-07 thru Oct-11) ~661 FTE months
      - ~ 115 FTE months of this estimate are not currently funded
    - Zero contingency included in the DESDM project.
- CFIP –
  - CFIP is estimated at $390K for equipment upgrades and $470K for labor ($860K total).
  - Lower-than-planned funding levels resulted in prioritizing upgrades as “core”, “stretch” and “wish list”. All DECam support items are identified as “core”.

Cost Estimate - Comments

- DECam Cost Estimate –
  - Prior to CD-2 approval, ~$2.3M was added to DECam baseline (engineering, travel, contingency).
  - Basis of cost estimate is documented in doc-db. Updated when new information is available.
  - Current cost + contingency appear adequate to deliver CD-4 deliverables.
- DECam Cost Performance to date –
  - 12 months of earned-value reporting. Management is using EV effectively in its decision-making.
  - Change orders to date have been modest and documented.

Cost Estimate - Comments

- DESDM Cost –
  - Estimate primarily consists of labor costs supporting a software project.
  - Management has prioritized its components to ensure high priorities are ready for initial operations.
- CFIP Cost –
  - Primarily an upgrade to an operating facility.
  - CTIO ramping up resources. Director is committed to CFIP being ready for DECam.

Cost Estimate - Recommendation

1. Recommend CD-3b for DECam.

Schedule and Funding – Findings

- DECam –
  - Delivery to CTIO forecast Dec. 2010, Baseline March 2011
  - RFI on telescope: March 2011; Baseline Sept. 2011
  - Project complete (CD-4) Sept. 2012
    - ~16 months schedule contingency
- DESDM –
  - Schedule follows a series of spiral development cycles
    - Yearly Data Challenges with identified milestones
  - Community Pipeline test Summer 2010. Stress test Fall 2010
  - Commissioning/Acceptance Testing: Spring 2011
  - Operations: Oct 1, 2011
- CFIP –
  - Summary schedule presented.
    - ~12-15 months schedule contingency

Schedule and Funding – Findings

- DECam –
  - Funding-constrained schedule.
    - Major procurements planned in FY09
  - Presumed FY09 CR is problematic
    - Planned obligations exceed funding under a CR
- DESDM –
  - Planned NSF proposal for necessary manpower.
- CFIP –
  - CTIO funding forces deferral of capital expenditures until FY09, possibly FY10. No impact to DECam.

Schedule and Funding – Comments

- DECam, DESDM and CFIP are managed as separate projects. However, DES management is working to tie the projects together with an integrated project schedule.
- DECam –
  - Schedule performance good. SPI ~0.95, CPI ~0.98
  - DECam schedule contingency is adequate.
  - Continuing resolution is a worry
    - Look at FY09 “swing” procurements (risk-based)
    - FNAL management (PMG) is actively engaged in helping

Schedule & Funding - Comments

- DESDM –
  - Funding needed to provide DM for early ops.
    - Priority 2 and 3 items may fall off otherwise
  - .2 FTE for project management is not adequate to manage overall project.
  - Holding to schedule for 2011 operations
- CFIP –
  - Steadily ramping up resources and making good progress.
  - Schedule performance meeting

Schedule and Funding – Recommendations

1. DECam - Prioritize (according to risk)
   a) list of planned FY09 procurements
   b) list of late FY09 procurements that can be deferred should additional contingency be necessary to address overruns and/or CR.
2. DECam - Recommend CD-3b

DOE/NSF Review of the Dark Energy Survey (DES) Project

Management

Kem Robinson, LBNL

Eloquently delivered by

Mark Reichanadter, SLAC

Management (1)
Findings

- Global MOU was signed May 14, 2008 by all parties
- CD-3a was approved by DOE after receipt of signed Global MOU
- Risk registry has been updated and tightened
- Issues logs are used as active management tools within DECam
  - Ongoing, Technical, Integration
- DES Systems Interface Working Group is to be formed
- Communication is in strong evidence and the DECam project manager provides a strong integrating role for both DECam and DES as a whole
- Project control processes are in place, fully functional, and used for managing within DECam
- DES Project has more integrating functions and processes in place
- DECam project is rigorously managing to its performance baseline

Management (2)
Comments

- The committee believes that the state of the project is ready for full construction authorization in both documentation and management systems
- The committee endorses DOE pursuing CD-3b for DECam Project
- The DES Project Office has increased its integrating activities
- In general, the DES Project has been responsive to previous review recommendations
  - DES Project – Some recommendations still under implementation
  - DECam – Fully responsive and implemented
  - CFIP – Responsive
  - DESDM – Indeterminate, (not highlighted in materials given to committee)
- The committee is pleased to see the Global MOU is signed and being actively executed
- The project teams are functional and strong or strengthening
  - DECam is being effectively managed at a level appropriate for a project of this size and complexity
  - CFIP has increased its project management rigor
  - DESDM has made some progress, but more rigor to meet deliverables is warranted

Management (3) Comments

- A degree of integration between all three elements (DECam, DESDM, and CFIP) is present - not been seen previously
- DESDM has inadequate project management and risk management rigor given the scope, deliverables and complexity of the project
- The integration efforts have improved
  - The telescope simulator is of particularly noteworthy greatly reducing at telescope integration risks
- Configuration management formality isn't as well established or mature as the committee would like to see at this point of a project, but progress in this area is accelerating. The project, however, does not appear to be suffering too much from this at present (e.g. # of filters).
- Risk management awareness as a tool has increased
  - Need to examine impacts on risk in other areas when mitigating risks, e.g. filter procurement delays to accommodate CR
  - Don't delay higher risk procurements as they have the greatest probability of impacting cost / schedule

Management (4) Recommendations

(all before next review)

1. Ensure that nomenclature used throughout the project is consistent and clear to reduce potential miscommunications.
2. DESDM - Recommend adding resources for added project and risk management (as much as ~1 FTE)
3. Develop a risk-based procurement timing strategy in response to inevitable extended continuing resolution situation
4. Examine the subcontract/vendor controls/communication to minimize schedule and cost risks.
5. Reexamine both the integration and configuration controls in place throughout the DES Project to ensure adequacy. This includes initiating the DES Project Interface Working Group as soon as possible.
6. Proceed with obtaining CD-3b for DECam Project.