

LSST Annual Project Report FY 2009  
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The LSST is a proposed large-aperture, wide-field, ground-based telescope designed to obtain sequential images of the entire visible sky every few nights. The optical design involves a 3-mirror system with an annular 8.4-m primary; the effective collecting area is equivalent to a 6.7-m diameter unobstructed primary. The mirror system feeds three refractive correcting elements inside a camera, providing a 10 square degree field of view sampled by a 3 Gigapixel focal plane array. The total effective system throughput,  $A\Omega = 318 \text{ m}^2 \text{ deg}^2$ , is nearly two orders of magnitude larger than that of any existing facility. The survey will yield contiguous overlapping imaging of more than 20,000 square degrees of sky in 6 optical bands covering the wavelength regime 320-1080 nm.

In 2003, the LSST Corporation was formed as a non-profit 501(c)3 Arizona corporation with headquarters in Tucson, AZ. At the time of this report, membership has expanded to twenty nine members including Brookhaven National Laboratory, California Institute of Technology, Carnegie Mellon University, Chile, Columbia University, Drexel University, Google Inc., Harvard-Smithsonian Center for Astrophysics, Johns Hopkins University, Kavli Institute for Particle Astrophysics and Cosmology - Stanford University, Las Cumbres Observatory Global Telescope Network, Inc., Lawrence Livermore National Laboratory, Los Alamos National Laboratory, National Optical Astronomy Observatory, Princeton University, Purdue University, Research Corporation for Science Advancement, Rutgers University, Space Telescope Science Institute, SLAC National Accelerator Laboratory, The Pennsylvania State University, The University of Arizona, University of California at Davis, University of California at Irvine, University of Illinois at Urbana-Champaign, University of Pennsylvania, University of Pittsburgh, University of Washington, and Vanderbilt University.

This fourth annual report of the LSST Project summarizes major activities and findings for the period September 1, 2008 through July 31, 2009.

### 1. Major Research and Education Activities and Findings

- Version 1.0 of the LSST Science Book was completed in June 2009; after final edits, the 554-page book will be published for public distribution in October 2009. The Science Book develops in detail over one hundred science missions that require telescopes with enormous etendue.
- LSST Science Collaboration Teams completed the first call and issued a second call for participation, inviting interested members of the US astronomy and physics communities to participate in shaping the science for the LSST survey.
- On December 2, 2008, Chilean authorities unanimously accepted the LSST environmental impact declaration granting the project the permits necessary to build and operate the telescope on Cerro Pachón. This action clears the way for LSST to begin construction immediately upon funding availability.
- Back surface grinding on the M1/M3 mirror at the UA Steward Observatory Mirror Lab (SOML) was completed. SOML is now processing the surface with ever smaller grit to polish the back surface to final specification. This work is privately funded.
- Corning successfully fused the M2 substrate on March 13, 2009 and subsequently slumped and annealed the substrate in July; this work is privately funded.

- LSST acquired, with non-federal funds, the 1.2-meter diameter Calypso Telescope from Edgar Smith in November, 2008. LSST will use the telescope in its current location on Kitt Peak to conduct unique scientific investigations in support of calibration plans and to prototype hardware and software components. In the future, LSST plans to move the telescope to Chile to use it for atmospheric monitoring.
- The membership of LSST Corporation increased to 29 members with the addition of 5 new members since the last annual report.
- The LSST “Policy and Procedure Manual” has been completed. Advance copies were sent to the NSF to complete the submission package necessary to qualify the LSSTC to receive NSF funds directly.

## 1.1 Project Management

- The systems engineering group reviewed and updated the technical risk assessment in the project. Eight key technical risk areas were identified:
  1. Large Optics Fabrication; includes filter fabrication, M2 and M1M3 metrology,
  2. Camera Mechanisms; includes shutter and filter exchange mechanisms,
  3. Camera Cryostat & Focal Plane; includes science sensors performance and procurement, FPA assembly flatness, and out gassing in cryostat,
  4. Thermal Management; includes heat leakage by the camera into the optical path and maintaining thermal control over M1M3,
  5. System Automation; includes active optics wavefront sensing and error reconstruction,
  6. Camera Support; includes hexapod and rotator stiffness and precision,
  7. Science Algorithms; includes efficiencies in data quality assessment and database schema and implementation,
  8. Database & Process Reliability & Scaling; includes database performance with huge ( $10^{12}$ ) row count and overall DM system performance with geographically distributed elements.
- Eight documents were commissioned by the project manager to initiate the formal review and configuration control process. 7 of the 8 documents have been completed, their status follows:
  1. Science Requirements Document: This document is completed and approved.
  2. Configuration Management Plan: This document details the responsibilities and process for configuration control. It has been completed and is under review by the PMO.
  3. Systems Engineering Management Plan: This document outline the responsibilities, roles and processes for the project Systems Engineering effort. It has been completed and is under review by the Systems Engineering group.
  4. Software Development Plan: This document details the software development standards to be used across the project for all software deliverables. The Software development plan consists of 4 documents: The software Development Plan overview; LSST Software quality assurance Guidelines; LSST Software Configuration Management Guidelines; LSST Software Verification and Validation Guidelines. All 4 documents are completed and under review by the Systems Engineering group.

5. **Optical Design Document:** This document details the prescription and basic performance of the LSST optical system. It has been completed and reviewed by the Telescope and Camera teams. Following minor changes this document will be approved and under configuration control.
  6. **Calibration Plan:** This document details the baseline process design and requirements for the complete photometric calibration of LSST science data. The document is under significant revision based on the calibration review (see below). A complete draft of the revised document is due in August, 2009.
  7. **Safety Plan:** This document details the responsibilities and procedures to ensure the LSST project is safely executed. The document has been completed and is under review by the PMO.
- A revised work flow for implementing Configuration Management and Change Control in the LSST DocuShare archive was approved by the Engineering Management group.

## 1.2 Science and Simulations

- Version 1.0 of the LSST Science Book was completed in June 2009; after final edits, the book will be published for public distribution in October 2009. The 554-page Science Book develops in detail over one hundred science missions that require telescopes with enormous etendue. All together, there were nearly 200 contributors for the 15 chapters in the Book. Zeljko Ivezic, Michael Strauss, Tony Tyson, and Sidney Wolff contributed their scientific leadership and editorial skills. Anna Spitz from LSSTC and Michael Sivertz from BNL invested many hours in editing the book for publication. Work on the book began at an LSST retreat held December 10-14, 2008 at Friday Harbor Laboratories, Friday Harbor, Washington where 50 scientists completed a draft document.
- LSST has participated fully in the Astro2010 Decadal Survey Review Process:
  - Tony Tyson and Don Sweeney submitted a fact sheet on the LSST project status requested by the NRC for the 2010 Decadal Survey committee. This is the first documentation the project submitted to support the Astro2010 Decadal Survey.
  - Teams of LSST scientists and engineers prepared a written response to the eight questions raised by the Astro2010 Program Prioritization Panel, June 2009.
  - The LSST management team and staff organized and submitted a 35 page response the Astro2010 Decadal Survey OIR panel, June 2009. Tony presented the LSST response to the Astro2010 Decadal Survey OIR panel in Pasadena in a Q&A face-to-face on June 8, 2009. Several members of the LSST management team at the meeting discussed the LSST project with Astro2010 Decadal Survey members, Program Prioritization Panel members, and with officials from DOE, NASA, and NSF.
  - The LSST team submitted a 58-page document responding to questions from the ASTRO-2010 Decadal Survey, July 27, 2009. Future requests are expected.
- LSST research ideas were addressed in sixty-three of the Science White Papers submitted to the NRC/NAS Astronomy & Astrophysics 2010 Decadal Survey in mid-February. An additional 20 State of the Professional papers mention LSST.

- LSST Science Collaboration Teams completed the first call and issued a second call for participation, inviting interested members of the US astronomy and physics communities to participate in shaping the science for the LSST survey. The first general call was completed in September 2008 in which 40 proposals were received with 60 individual applicants. Of these, 26 proposals were accepted, with 36 new individual members. The latest announcement was made by LSST, NOAO, and SLAC in July of 2009 for additional members and proposals for entirely new collaboration groups; further details are available at: [http://www.noao.edu/lstt/collab\\_prop/Scicollab.htm](http://www.noao.edu/lstt/collab_prop/Scicollab.htm)
- The Image Simulation group delivered 1200 simulated CCD images to the Data Challenge 3a (DC3a) team. These images were for 19200 amplifiers formatted to work with the DM pipelines together with the ancillary catalogs and information describing the image parameters. To date the group has simulated over  $10^{13}$  LSST photons.
- The image simulation requirements document to support DC3 was finalized with agreement from both the DC3 and image simulation groups. The interim goal is an initial test run of data (several CCD's) that will be passed through the data management pipelines to check that the formats are correct and the metadata is in place. On validation, a full set of simulations will be run and delivered (1200 CCD images).
- An initial set of image catalogs was developed for testing DC3 images at Purdue. These include galaxies (from the Millennium catalog) to  $r=28$  and stars (from the Jones and Ivezić catalogs) to  $r=28$ . Current galaxy models include a simple bulge-to-disk model for sources in the catalog.
- The image simulations group completed the World Coordinate System (WCS) routines to fit individual images with a common reference. The routines apply the WCS to the image header for proper processing in the DC3 pipelines.
- The “OpSim Sky tool” has been completed to augment the Operations Simulation toolbox. This query tool works with the operations simulator to provide its simulated sky conditions (clouds, moon, seeing, etc.) based on position, time and filter for additional analysis.
- The Operation Simulation group completed modification to the Op Sim website as a forum focused solely on distributing data and information pertaining to the simulated surveys. From this portal the survey results and associated Simulated Survey Analysis Report (SSTAR), upgraded to V3.2.2, are available for scientific review. See: <http://www.noao.edu/lstt/opsim/>
- The first 8 runs of an operational simulator investigation into instrument model parameters have been completed using a matrix of perturbations that define the performance of the telescope, dome, optics, and camera to assess the sensitivity of the survey to specific parameters.
- The operations simulation group has completed a new baseline 10-year simulation. The variation in results to the previous baseline, “Cronos 92”, analyzed so far are consistent with the changes made in shutter time, scheduled down time, and proper dome motion. Additional runs are in progress to optimize the results with the new instrument model. This stable version of the code is also being used to run the simulations requested by the Science Council.
- A review of progress on the LSST Operational User Cases was held on January 14, 2009 and included 155 use cases in the LSST SysML Operations model, 35 DM/Science operational uses cases and 120 Observatory operational uses cases.

- Subsystem managers, systems engineers, and scientists met May 6-7, 2009 at Harvard for a review of the photometric calibration approach and process.
- Systems engineering reviewed the status of the camera-telescope mechanical interface during a 2-hour teleconference held May 18, 2009. It is ready for formal review so that it can be put under configuration control.
- A 1.5 day workshop among CCS, DM, OCS, and TCS to review the state of interface requirements analysis and documentation among the LSST subsystems was held in Tucson May 21-22, 2009. The entire existing sets of interface requirements in the SE model were reviewed in real time.
- Early draft documents derived from the SysML model for the System Functional Requirements and the Functional Requirements for each of the three subsystems have been produced.

### 1.3 Telescope and Site

- Back surface grinding on the M1/M3 mirror at SOML was completed. SOML is processing the surface with ever smaller grit to polish the back surface to final specification.
- LSST finished the drawing package for the M1/M3 laser tracker fiducial hardware. This system allows laser trackers on the telescope to determine mirror positions.
- LSST awarded a contract for the fabrication of the M1/M3 laser tracker fiducial hardware to Landmark Tool & Gage. Landmark previously fabricated and delivered all LSST loadspreader assemblies and flexures. LSST will provide the twelve assemblies to SOML in August 09 for bonding onto the mirror bosses. This hardware is privately funded.
- LSST received all the hardware for the M1/M3 thermocouple (TC) control system. 400 TCs were calibrated to 0.1C accuracies and delivered by GEC Instruments. One hundred forty-six of the 400 will be delivered to SOML for bonding on/within the M1/M3 glass, with the remainder of TCs held for eventual distribution throughout the telescope. This hardware is privately funded.
- The M1/M3 mirror thermal control system preliminary design is complete and a draft document archived.
- Corning successfully fused the M2 substrate on March 13, 2009. The secondary mirror passed the process inspection (payment Milestone #4) and will be ground to final shape and acid etched. The 8 machined ULE petals were assembled in the furnace where the temperature was elevated to ~1800 C, fusing the pieces into the single 3.4 meter LSST substrate. Corning removed the M2 substrate from the 8-meter furnace after detailed inspection revealed no issues with the fusion seals.
- The M2 transport container/turnover box was delivered to Corning. Initial grinding of the M2 substrate to an oversized plano / plano configuration was completed, a convex contoured sag form is being generated, and the 8-meter furnace is being prepared for the second high fire slumping operation.
- The M2 substrate was slumped and annealed to a near net shape. The part passed in-process inspections and is being prepared for grinding and etching in August 2009. All work on the M2 substrate at Corning is privately funded.
- A hardware prototype lab area was completed for LSST work at NOAO and M1/M3 actuator and support hardware testing has begun. The hardware design and testing

continues in collaboration with LBT, as they rework existing hardware, and with GMT as we both consider designs for the LSST generation of borosilicate mirrors.

- A calibration screen projector design was completed for a system that is not sensitive to the non-uniformity of the engineering diffuser. Prototype tests at Harvard continue to support the design process.
- The summit civil engineering work contracted to ARCADIS Geotechnica in Santiago was completed. They delivered a full specification and procurement package for soliciting the early excavation and road development on site. The telescope and site team is ready to procure this work when \$ 1M in funding can be made available for this purpose.
- Mirror reflective coating tests were completed at the Gemini North coating facility in Hawaii. All plates were coated successfully without dramatic increases in temperature or stress.
- A team from LSST and the University of New Mexico completed the development and installation of micro-thermal equipment on Cerro Pachón. The system has been run for many months and results are being analyzed. Initial indications are very positive on the operation of the system.
- The primary mirror cell design effort has achieved the target weight and structural performance. Significant design and analysis was completed to achieve a cell weighing less than 55,000 lbs that can both support the mirror with sub-millimeter deflections under vacuum chamber forces.
- Analysis of two calibration screen approaches was completed; a review has led to a single choice to pursue for prototyping. The telescope group will collaborate with Chris Stubbs at Harvard to build a small-scale demonstration of a direct illumination projector to test performance.
- A simulation and analysis of the corner raft requirements was completed. The report describes analysis of the telescope-imposed guider requirements and tests using the Cadence Simulator statistics for generating test cases.
- On December 2, 2008, Chilean authorities, representing 17 government agencies, unanimously accepted the LSST environmental impact declaration granting the project the permits necessary to build and operate the telescope on Cerro Pachón. This action clears the way for LSST to begin construction immediately. With the civil engineering work for initial site excavation also completed, LSST can begin site development as soon as funding is available.
- A contract was established and finished with Puga Mujica Asociados (PUMA) for a summit facility technical and cost review. PUMA built the SOAR facility on Cerro Pachón and offered unique experience to provide a technical assessment of the summit facility concept and a fresh cost estimate to inform the project before it starts the formal A&E work in fall 2009. The initial scope of effort was delivered and a small additional effort is underway.

#### 1.4 Data Management

- The Data Management group completed Data Challenge 3a (DC3a) and has begun planning for DC3b. DC3a is the third in a series of prototypes of the LSST Data Management system through which solutions to the most challenging technical problems are prototyped and validated. Details of the production runs include:

- Performed 36-node/288-slice runs on NCSA ABE cluster. This represents 10% of the true LSST focal plane size and is processing entire CFHT images in parallel (12 out of 85 visits). In order to go to larger parallelization/data volume, we must clone the CFHT data and fix a limitation in the Event System. Finished runs of CFHTLS Deep data and simulated LSST images (31 LSST amp-equivalents) with expected results. Simulated images contain no variable sources, so nothing to difference image or associate. All stages up to difference imaging ran successfully.
- Processed CFHTLS Deep data (30 LSST amp-equivalents), 4 minutes per visit. This is a 100% performance improvement over the last status, primarily due to optimizations to difference imaging stages.
- Worked with Image Simulation Group to prepare LSST simulated images and catalogs for production runs. Ran small number of images through Image Processing Pipeline with results as expected
- Conducted Science Data Quality Analysis of results. Debugged and fixed astrometric problems.
- Conducted DC3a post-mortem meeting and published results in DC3b Scoping meeting. Thirty attendees from all DM partners involved in DC3a or coming on board in DC3b (U Penn).
- Created and populated a data archive at NCSA for photometric calibration data and conducted tests to determine systematic effects in calibration data.
- Completed Instrument Signature Removal (Saturation Correction, Correct and Trim, Correction, Current Correction, Linearization, Flat Field Correction, Illumination Correction, Fringe Correction) and Image Co-addition pipeline stages, and updated the Image Subtraction pipeline stages.
- A review of the Data Management Functional Requirements Specifications (FRS) was held during Feb. 7-8, 2009 at UC Davis, Davis, CA to clarify the boundary between LSST DM deliverables and work the astronomical and physics communities would do on their own. This meeting was attended by representative from the PMO, EPO, DM, the LSST Science Council, and representatives from each of the Science Collaborations. One outcome from the review meeting is that the project would make available a common set of tools that would enable Level 3 development.
- Completed the DM Requirements Summary which is to be sent to the Science Collaborations. An executive summary of this document was provided to the LSSTC Board.
- Conducted Scientific Data Quality Assessment (SDQA) scoping meeting to clarify the role of SDQA system in both Science Data Quality Assessment (primary mission) and DMS pipeline validation (secondary mission).

## 1.5 Camera

Funding for the LSST camera comes from non-NSF sources. SLAC is the lead institution. For completeness, we include these items from the camera team:

- *Two major Camera Team meetings were held this period to discuss sub-system status, critical issues, risk management, cost/schedule and plans for the DOE CD-1 and NSF PDR. The meetings were at SLAC September 16-19, 2008 and at Harvard University on May 4-5, 2009,*

- A draft *Interface Control Document (ICD)* between CCS and Observatory Control Systems was completed as well as between CCS and Data Management
- An initial *Preliminary Hazard Analysis Report* was completed with the SLAC Safety Engineer, along with initial completion of the Hazard List.
- During this period progress was made on the sensor characterization. The 1K x 1K STA1759A sensor was mounted in a dewar, then tested and found to have amplifier problems that are being repaired. The e2V study contract sensor 106-06 was re-mounted into the test Dewar and cooled down for characterization .
- Significant progress for the sensor characterization on the raft towers has been made. A series of optical point spread function measurements on the e2v pre-prototype have been completed and the Fringe Projector Interferometer measurements and analysis programs for direct MTF measurement have been improved.
- The e2v final sensor design report for the *Sensor Prototype* has been received and approved. Definitions of clock, bias, and video interface to the e2V sensor package have been determined.
- Completed assembly of the 16-channel, 500kpix/s CCD controller for the sensor characterization facility.
- Installed the STA1759 study contract sensor in the characterization test bench and began preliminary functional tests.
- Preliminary characterization of the prototype silicon carbide raft was completed. Design for SiC sensor proxy and differential adjustors completed and SiC sensor proxies and adjustor prototypes from ECM were ordered. Fixtures for the new raft prototype components were designed.
- Progress continued on the raft metrology. The purchase order for the CeSiC differential screws and dummy sensors was placed with ECM. The hardware design for the raft hold-down in the metrology station and for the room-temperature dummy sensors were completed. The design of raft mount in the cryo-metrology dewar was completed and parts were received from Harvard for the raft mount. A raft with five dummy sensors was installed and adjusted using the differential screws.
- IN2P3 received prototype quantities of the ASPIC-II chip and reported 100% functionality. This chip is the second version of "Analog Signal Processing ASIC" to be used on the Front End Boards (FEBs).
- Extensive electronics review of the Science Control Crate (SCC) was completed including detailed simulations of all analog blocks. This review included representatives from BNL, Harvard, and University of Tennessee.
- The preliminary design for the guider data flow was completed and the conceptual design of the wavefront electronics was refined. A conceptual design for the raft/tower insertion tool has been designed and procedure has been created along with a draft of the assembly sequence.
- The workstation for safe handling of the CCDs has been assembled, an additional storage cabinet for the LSST test station has been installed and a custom stand for the turbo pump vacuum station has been built. LabView programming for environmental controls of the LSST test station are complete.

- *Purdue shipped the parts for the LSST Guider Test-Bed to SLAC to be used in the cryostat activities at Calypso. During a site visit, the cryostat activities were evaluated and coordinated with NOAO personnel.*
- *Completed a conceptual design of new mixed-refrigerant cryogenic cooling system for the cryostat. Discussions have been initiated with MMR Technologies for prototyping the system this year.*
- *The team completed mechanical design of Raft Control Crate and began machining of second prototype.*
- *The full update of the camera finite-element analysis model with the addition of significant details including all refractive lenses was completed. This will now be used to analyze the expected deflection and distortion of optical elements due to re-pointing.*
- *The camera team completed the design study of the Grid perimeter frame to support the ECM manufacturing study. This included changes to the perimeter frame for improved manufacturability to use CeSiC for the flexure support block.*
- *The grid design study at ECM started and SLAC received Technical Note 1. Issues raised in this note were analyzed and addressed by SLAC and ECM started the fabrication of a plastic model.*
- *The camera team completed revision of Raft Tower Interface Definition Drawing. This is intended to capture all mechanical interfaces between the science raft towers and the cryostat, and is based on the current design of the raft tower from of BNL. Drawing was sent out for review.*

## 1.6 Education and Public Outreach

- The Google Analytics tool was implemented on the public website for quantitative tracking of website activity. Website traffic at [www.lsst.org](http://www.lsst.org) is increasing and now stands at approximately 4800 hits per month with 65% of the hits from new visitors. The average time spent on site is almost three minutes with the average number of pages viewed per visit at 3.82.
- The LSST quarterly E-News is in its second year of publication, the sixth issue, with a mailing list of approximately 3300 addresses, some of which are group aliases. Articles are visited online, using the “Read More” link in the email version of the newsletter, just over 700 times an issue.
- Three LSST FaST teams were in place for the summer. At UW, Andrew Becker worked with professor Hakeem Oluseyi and two undergraduate students from Florida Institute of Technology on transient detection software. At BNL, Paul O’Connor’s sensor team worked with Ray O’Neal and two students from Florida Agricultural and Mechanical University (FAMU). At SLAC, Dave Burke worked with J. Allyn Smith and two students from Austin Peay State University on the calibration effort.
- LSST issued Press Release LSSTC-08 on September 2, 2008. The release featured a group photo taken around the LSST mirror blank on the SOML oven hearth.
- Corning Inc. issued its press release “Corning to Manufacture Secondary Mirror Substrate for LSST” on March 11, 2009. Coverage of the release was primarily in business and technical websites, not science.
- LSST was featured on the March 2009 page of the American Astronomical Society (AAS) calendar.

- The Steward Observatory Mirror Lab has reactivated their Public Tour Program. Docent led tours feature the LSST M1M3 mirror and involve about 200 participants per month.
- Spanish and English versions of the LSST tri-fold brochure were updated, printed, and staged on the public website for download at <http://www.lsst.org/lsst/about/brochure>

## 2. Major Findings

Conclusions that have emerged from FY09 activities are included in the previous text describing Activities.

## 3. Opportunities for Training and Development

- Several vendors for project training in SysML were interviewed. SysML provides a formal process for model-based engineering and management of complexity. Cris Kobryn (Chair of the OMG SysML panel) of PivotPoint Technology presented onsite SysML training in Tucson July 27-31.
- LSST hosted Xerox Corporation system engineers for a week-long DocuShare customization effort. The effort resulted in improvements to the existing document configuration control system, additions of system metadata to documents, and other customizations added to the new release, DocuShare 6.0.
- Project Architect Jeff Barr completed requirements and is now an Accredited Professional for Leadership in Energy and Environmental Design (LEED), insuring LSST incorporates up-to-date standards and best practices in the summit and base facility designs.
- A 3-day training and planning meeting led by Bruce Truax was held for the Calypso telescope attended by engineers and scientists from LSST institutions and Texas A&M. Elaine Halbedel, former contract employee to Edgar Smith, was hired to be the Calypso Observing Associate.
- Graphic Designer Emily Acosta completed a one-semester course on Digital Video Editing, to add that capability to the LSST Outreach efforts.

## 4. Outreach

- **Outreach to Professional Community:** LSST had a strong showing at the 213th meeting of the American Astronomical Society (AAS), which took place January 4-8, 2009, in Long Beach, CA. LSST had a large display on the exhibit floor and a special poster session where 30 posters were presented covering all aspects of the project. All of the posters are available on the LSST public web site. LSST also sponsored a booth at the AAS Summer Meeting in Pasadena, CA, June 7-10, 2009.
- **Congressional visits:** Don Sweeney, Chuck Claver, Gregory Dubois-Felsmann, and Andrew Becker met with congressional representatives (or staff) during FY2009. Andrew Becker visited offices in April as part of the AAS-sponsored Congressional Visit Day. Gregory Dubois-Felsmann went to Washington, DC, as part of the annual SLAC Users Group trip to meet with Congressional representatives. He met with Gabrielle Giffords staff member Elaine Ulrich, who holds a PhD in Optical Sciences from the UA, and (briefly) with Giffords herself. Don Sweeney and Chuck Claver traveled to Washington, D.C. to participate in a March 24 event on Capitol Hill for the Coalition of National Science Funding (CNSF); LSST's participation was sponsored by the American Astronomical Society. Nancy Pelosi attended the event held in the Rayburn House Office Building and gave a short speech emphasizing

her commitment to science and the NSF in particular. During the day, Don and Chuck met with a number of congressional staff members and congressional committee staff members. (See E-News, April 2009, for details)

- Tony Tyson attended the inauguration of the Gran Telescopio Canarias, a 10.4m telescope on the Canary Island of La Palma, Spain. Tony presented an invited paper on the LSST in the ELT era.
- A number of LSST staff members attended the three week Wide-Fast-Deep Frontier workshop at the Aspen Center for Physics, Aspen, Colorado, Summer, 2009.
- Tony Tyson presented invited presentations on LSST to the APS California section meeting in Los Angeles on October 18 and the APS DNP meeting in Oakland, California on October 24, and at the UC-Davis Centennial celebration.
- Tony Tyson, supported by a number of LSST staff members, gave a presentation on November 25 to the NASA/DOE JDEM Science Coordination Group on the complementarities of JDEM and LSST for dark energy science.
- Team members attended IVOA Interop 2008. The conference was well-attended and there is still a lot of VO activity in institutions in US, Europe, and Japan.
- Team representatives delivered two presentations at the 2008 ADASS Conference, entitled "Designing the Science Data Quality Analysis (SDQA) Subsystem for the LSST Project" and "Towards Efficient Analysis of Astronomical Data at Peta-scale". Team representatives co-lead a Birds of Feather session entitled "Future Astronomical Data Reduction and Analysis Software". ADASS remains the conference where the most interesting astronomy software developments are presented. Team representatives met with STScI/JWST team regarding sharing pipeline technology, and cross-evaluation will start in 2009.
- DM team conducted second eXtremely Large Data Base (XLDB) conference.
- Michael Wood-Vasey (University of Pittsburgh) spoke about LSST as a guest on the KMOX Radio show Overnight America hosted by Jon Grayson on March 5th. The show is carried on three Clear Channel satellite radio stations and reaches up to two hundred thousand listeners (<http://www.kmox.com/pages/3582439.php>). Our public website experienced a one-day spike (doubling) in traffic due to this exposure.
- John Oliver gave a presentation on the LSST camera at the "Seventh International Conference on Front End Electronics" June 2008.
- Ian Shipsey gave an invited talk on the LSST project and research opportunities at the Louis Stokes Alliance for Minority Participation Indiana & Midwest Crossroads AGEP "League of Extraordinary Students" Fourth Annual Joint Conference, West Lafayette, Indiana, November, 2008.
- Ian Shipsey gave an invited talks on the LSST project at the American Physical Society April Meeting, St Louis, April, 2008, the International Conference on High Energy Physics, Philadelphia, August 2008, and a presentation on the LSST Camera at the IEEE Meeting in Dresden Germany, October, 2008.
- Kirk Borne presented a talk on Data-Driven Cyber-Enabled Science for the US Library of Congress e-Science Group. An intense discussion of LSST, Citizen Science, Distributed Annotation Systems (DAS), and Galaxy Zoo ensued.

## 5. Journals

- Abbott, T.M.C., Schumacher, G. Warner, M. et al. (2008) Cerro Tololo Inter-American Observatory, Victor M. Blanco 4-m Telescope: an upgrade to the telescope control system. *Proc., of SPIE*, 7012.
- Anderson, E.H., Glaese, R.M., Neill, D. (2008) A comparison of vibration damping methods for ground based telescopes. *Proc. of SPIE*, 7012.
- Borne, K. D. (2008) A machine learning classification broker for the LSST transient database. *Astronomische Nachrichten*, 329: 255-258.
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## 6. Books and Other One-Time Publications

- The July 2009 issue of National Geographic includes text and photographs about LSST in an article titled “Cosmic Vision” written by Timothy Ferris describing “a new generation of giant telescopes”.
- Suzanne Jacoby and Philip Pinto coauthored an article about LSST for publication in the Interstellar Studios online newsletter:  
[http://www.400years.org/newsletter/400\\_news\\_0509.pdf](http://www.400years.org/newsletter/400_news_0509.pdf) Interstellar Studios produced the PBS documentary 400 Years of the Telescope; the newsletter is a production of the US International Year of Astronomy (IYA) 2009 Program.

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- Wood-Vasey, Michael (2009) Educating the Next Generation of Leading Scientists: Turning Ideas into Action. *Astro2010: The Astronomy and Astrophysics Decadal Survey, Position Papers*, no. 66.
- Session Number 460 American Astronomical Society 11 January 2009
  - 460.01 [Overview of the LSST Observatory System](#)  
D. Sweeney (LSSTC/LLNL), J.A. Tyson (UCD), T. Axelrod (LSSTC), C.F. Claver (NOAO), K. Fouts (SLAC), D.K. Gilmore (SLAC), Z. Ivezic (UW), S.M. Kahn (SLAC), J. Kantor (LSSTC), V.L. Krabbendam (NOAO) and the LSST Collaboration
  - 460.02 [From Science to Design: Systems Engineering for the LSST](#)  
C.F. Claver (NOAO) et al.
  - 460.03 [LSST: from science drivers to reference design and anticipated data products](#)  
Z. Ivezic (UW), J.A. Tyson (UCD), T. Axelrod (LSSTC), D. Burke (SLAC), C.F. Claver (NOAO), S.M. Kahn (SLAC), R.H. Lupton (Princeton), D.G. Monet (USNO), P.A. Pinto (Steward/UA), M.A. Strauss (Princeton), C.W. Stubbs (Harvard), K.H. Cook (LLNL/NOAO), L. Jones (UW), A. Saha (NOAO), C. Smith (NOAO) and the LSST Collaboration
  - 460.04 [LSST: Cadence Design and Simulation](#)  
K.H. Cook (LLNL), P.A. Pinto (Steward), F. Delgado (CTIO), M. Miller (NOAO), C. Petry (Steward), L. Denneau (U. Hawaii), A. Saha (NOAO), P.A. Gee (UCD), J.A. Tyson (UCD), Z. Ivezic (UW), and L. Jones (UW), and the LSST Collaboration
  - 460.05 [Four LSST probes of Dark Energy](#)  
J.A. Tyson (UCD), H. Zhan (UCD), L. Knox (UCD), and the LSST Collaboration
  - 460.06 [Constraining Dark Energy with LSST Weak Lensing](#)  
W. Fang (Columbia/BNL), Z. Haiman (Columbia), M. Morgan (BNL), LSST Weak Lensing Collaboration

- 460.07 [The LSST Galaxies Science Collaboration: Nearby Groups and Clusters](#)  
H. Ferguson (STScI), L. Armus (IPAC), K. Borne (GMU), M. Dickinson (NOAO), E. Gawiser (Rutgers), D.K. Gilmore (SLAC), Z. Ivezic (UW), V.E. Margoniner (CSU), D. Norman (NOAO), M. Obric (UW), A. Rasmussen (SLAC), R. Roskar (UW), S. Schmidt (UU. Pitt), M. Seigar (UALR), A. Stanford (LLNL), M. Strauss (Princeton), R. Wechsler (Stanford/SLAC), J. Newman (UC Davis), J. A. Tyson (UC Davis), Zentner, A. (Pitt), LSST Galaxies Science Collaboration.
- 460.08 [Cosmology with Photometric Baryon Acoustic Oscillation Measurements](#)  
H. Zhan (UCD), L. Knox (UCD), and J.A. Tyson (UCD) and the LSST Large-Scale Structure/Baryon Oscillation Science Collaboration
- 460.09 [Photometric Redshift Calibration for LSST](#)  
S.J. Schmidt (UCD), J.A. Newman (UPitt), J.A. Tyson (UCD), A.J. Connolly (UW), D.M. Wittman (UCD), D.J. Matthews (UPitt), V.E. Margoniner (CSU), A. Choi (UCD), I. Udaltsova (UCD), LSST Collaboration
- 460.10 [Mapping the Milky Way and Near Field Structure with LSST](#)  
J. Bullock (UC Irvine), B. Willman (Haverford College), C. Grillmair (Spitzer Science Center), Z. Ivezic (University of Washington), J. Kalirai (Space Telescope Science Institute), and J. Strader (Harvard-Smithsonian Center for Astrophysics), LSST Milky Way and Near Field Structure Science Collaboration
- 460.11 [Stellar Populations and Nearby Galaxies with the LSST](#)  
A. Saha (NOAO), K. Olsen (NOAO), D.G. Monet (USNO), LSST Stellar Populations Science Collaboration
- 460.12 [Active-Galaxy Science with the Large Synoptic Survey Telescope](#)  
W.N. Brandt (PSU), S.F. Anderson (UW), D.R. Ballantyne (GA Tech), A.J. Barth (UCI), R.J. Brunner (UI), G. Chartas (PSU), W. de Vries (Livermore IGPP), M. Eracleous (PSU), R. Gibson (PSU), R.F. Green (UA), M. Lacy (IPAC), G. Madejski (SLAC), D.P. Schneider (PSU), O. Shemmer (UNT), H.A. Smith (CfA), P.S. Smith (UA), D.E. Vanden Berk (PSU), LSST AGN Science Collaboration
- 460.13 [Transients and Variable Stars with LSST](#)  
R.L. Jones (UW), S.R. Kulkarni (Caltech), S. Anderson (UW), A.C. Becker (UW), E. Berger (Harvard), J.S. Bloom (UCB), J. Bochanski (MIT), M. Claire (UW), K.H. Cook (LLNL), S. Kahn (SLAC), P. Szkody (UW), J.A. Tyson (UCD), W. Vestrand (LANL), LSST Transients and Variable Stars Science Collaboration
- 460.14 [Investigation of LSST Periodic Variable Star Lightcurve Recovery](#)  
H. Oluseyi (FIT), C. Culliton (FIT), M. Furquan (FIT), A. Becker (UW)
- 460.15 [LSST Strong Lensing: Galaxies and their Nuclei under a Gravitational Microscope](#)  
C. Keeton (Rutgers), G. Chartas (PSU), A. Roodman (KIPAC/SLAC), G. Dobler (CfA), C. Fassnacht (UCD), M. Oguri (KIPAC), LSST Strong Lensing Science Collaboration
- 460.16 [Cosmology, Clusters, and Chemistry: How Supernovae Trace and Shape the Universe](#)  
W. M. Wood-Vasey (Harvard), S. Olivier (LLNL), D. Cinabro (Wayne State), H. Zhan (UCD), R. Biswas (UIUC), Y. Wang (UO), P. Pinto (Steward/UA) , L. Wang (TAMU), LSST Supernova Science Collaboration
- 460.17 [Cataloging and Characterizing the Small Bodies of the Solar System with LSST](#)  
Steven R. Chesley (JPL), M. E. Brown (Caltech), J. Durech (Charles U), A.W. Harris (SSI), Z. Ivezic (UW), R. L. Jones (UW), Z. Knezevic (AO, Serbia), LSST Solar System Science Collaboration
- 460.18 [Calibration of LSST Instrument and Data](#)

- D. Burke (SLAC), T. Axelrod (Steward/LSSTC), J. Bartlett (APC Paris), D. Cinabro (WSU), C. Claver (NOAO), M. Creze (APC Paris), J. Frank (BNL), D.K. Gilmore (SLAC), J. Haggerty (BNL), Z. Ivezic (UW), L. Jones (UW), V. Krabbendam (NOAO), B. Meadows (U. Cincinnati), D. Monet (USNO), P. O'Connor (BNL), J. Oliver (Harvard), B. Popescu (U. Cincinnati), A. Saha (NOAO), A. Smith (APSU), C. Smith (NOAO), C. Stubbs (Harvard), J.A. Tyson (UCD)
- 460.19 [The LSST Camera System](#)  
K. Gilmore (SLAC), S. Kahn (SLAC), K. Fouts (SLAC), LSST Camera Team
- 460.20 [LSST Science Sensor Development](#)  
J. Frank (BNL), I. Kotov (BNL), P. O'Connor (BNL), S. Plate (BNL), V. Radeka (BNL), P. Takacs (BNL), J. Geary (CfA), K. Gilmore (SLAC), J.A. Tyson (UCD)
- 460.21 [LSST Camera Electronics](#)  
F. M. Newcomer (Penn), S. Bailey (LPNHE), C. L. Britton (ORNL), N. Felt (Harvard), J. Geary (CfA), K. Hashemi (Brandeis), H. Lebbolo (LPNHE), Z. Ning (UTenn), P. O'Connor (BNL), J. Oliver (Harvard), V. Radeka (BNL), R. Sefri (LPHNE), V. Tocut (LAL), R. Van Berg (Penn)
- 460.22 [Fabricating the LSST Mirrors: A Progress Report](#)  
J. Sebag (NOAO), W. Gressler (NOAO), D. Neill (NOAO), E. Heilmann (NOAO)
- 460.23 [LSST Telescope and Site Overview and Update](#)  
V. Krabbendam (NOAO), C. Claver (NOAO) J. Andrew (NOAO) J. Barr (NOAO), S. Chandrasekharan (NOAO), F. Delgado (CTIO), W. Gressler (NOAO), E. Hileman (NOAO), M. Ling (NOAO), M. Miller (NOAO), D. Mills (NOAO), D. Neill (NOAO), G. Schumacher (CTIO) M. Warner (CTIO) O. Wiecha (NOAO), LSST Collaboration
- 460.24 [Site Characterization of El Penon: Site of the Large Synoptic Survey Telescope](#)  
T. Chonis (U. Nebraska Lincoln), C. Claver (NOAO), J. Sebag (NOAO)
- 460.25 [Simulating the LSST](#)  
G. Jernigan (UCB), J Bankert (Purdue), A. Connolly (UW), E. Grace (Purdue), Z Ivezic (UW), M.J. Jee (UCD), L Jones (UW), M Juric (Princeton), S. Kahn (SLAC), V. Krabbendam (NOAO), A Meert (Purdue), S. Nichols (Purdue), J. Peterson (Purdue), J. Pizagno (UW), A. Rasmussen (SLAC), J.A. Tyson (UCD)
- 460.26 [How well can we measure galaxy shapes with the LSST?: PSF Modeling for 3.2 Giga Pixels](#)  
M. J. Jee (UCD), J. A. Tyson (UCD), J. Peterson (Purdue), D. Burke (SLAC), S. Kahn (SLAC), A. Rasmussen (SLAC), C. Claver (NOAO), D. Wittman (UCD), P. Gee (UCD)
- 460.27 [A Flat Focal Plane for LSST](#)  
A. Rasmussen (SLAC), C. Chang (SLAC), S. Kahn (SLAC), P. O'Connor (BNL), P. Takacs (BNL), R. Schindler (SLAC), M. Nordby (SLAC), LSST Camera Team
- 460.28 [Modeling Spatially Varying \(De\)Convolution Kernels for LSST Difference Imaging](#)  
A.C. Becker (UW), N. Silvestri (UW), R. Owen (UW), A. Connolly (UW), R. Lupton (Princeton), T. Axelrod (LSSTC)
- 460.29 [Petascale Object Classification of the LSST Event Stream](#)  
K. Borne (GMU), R. Laher (Caltech), Z. Ivezic (UW), N. Hamam (Caltech)
- 460.30 [Producing an LSST Data Release](#)  
T. Axelrod (LSSTC/U. Ariz), A. Becker (UW), J. Becla (SLAC), D. Burke (SLAC), A. Connolly (UW), R. Cutri (IPAC), G. Dubois-Felsmann (SLAC), Z. Ivezic (UW), J. Kantor (LSSTC), D. Levine (IPAC), K-T. Lim (SLAC), R. Lupton (Princeton), D. Monet (USNO), R. Owen (UW), R. Plante (NCSA), N. Silvestri (UW), J.A. Tyson (UCD), D. Wittman (UCD)

## 7. Internet Dissemination

- Public Web Site: <http://www.lsst.org>
- Project Web Site: <https://www.lsstcorp.org>
- Science wiki website: <http://www.lsstcorp.org/science>
- E-news: The LSST Quarterly Newsletter premiered in March 2008 and is archived online: <http://www.lsst.org/News/enews/archive.html>
- The LSST Telescope & Site group has developed a website that will provide site characterization information at <http://www.noao.edu/lsst/site/>
- A portal for the LSST DM Project software developers, including development plans, software standards, ticket tracking system, source code repository, software documentation is linked from the internal lsstcorp webserver at <http://dev.lsstcorp.org:8100/trac/wiki>
- The operations simulator website can be viewed at [www.noao.edu/lsst/opsim](http://www.noao.edu/lsst/opsim) (username=lsst, password=lsstsim).

## 8. Other Products

Nothing to report at this time.

## 9. Contributions within Discipline

See Section 1.0: Major Research and Education Activities and Findings.

## 10. Contributions to Other Disciplines

Nothing to report at this time.

## 11. Contributions to Human Resource Development

Nothing to report at this time.

## 12. Contributions to Resources for Research and Education

Spanish and English versions of the LSST tri-fold brochure were updated, printed, and staged on the public website for download at <http://www.lsst.org/lsst/about/brochure>

## 13. Contributions Beyond Science and Engineering

Nothing to report at this time.