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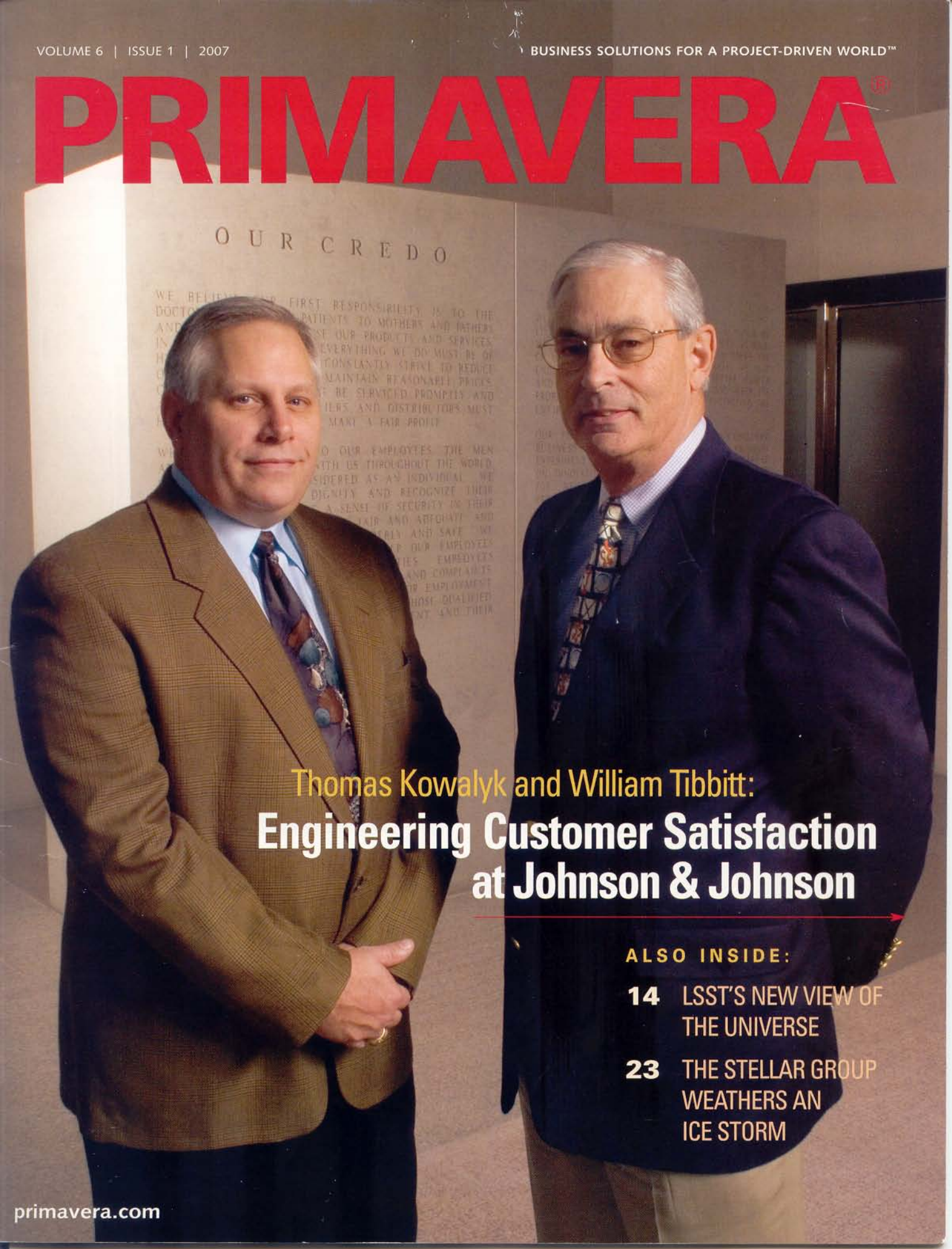

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A New View of Space: wide fast deep

Project managers use detailed cost, resource and scheduling estimation to prepare for construction of the Large Synoptic Survey Telescope, a five-year, $380 million project that will expand our window on the universe a thousandfold.

BY ROSEANN MCGRATH BROOKS

On a clear night, depending on where you live on Earth, you can view about 1,500 celestial bodies without telescopic assistance. But urged forward by our need to "boldly go where no one has gone before," educational, government, national laboratory and private organizations have joined together to design the Large Synoptic Survey Telescope (LSST) to give us a view of the sky in even more depth.

A proposed ground-based, 8.4-meter-diameter telescope with a very wide, 10-square-degree field of view, the new scientific instrument will provide time-lapse digital imaging of faint astronomical objects and will survey

the entire sky every three nights by taking 15-second exposures with a built-in 3 billion pixel camera. The telescope will be 50 times as powerful as other survey telescopes and will gather 7,000 DVDs' worth of data each night.

This data will be available to anyone with an Internet connection, from grade schoolers to world-renowned astronomers. It will be especially helpful to scientists studying objects that change or move rapidly, such as an exploding supernova, distant Kuiper Belt objects or near-Earth asteroids as small as 100 meters.

"Near-Earth objects are especially important to the U.S. government and they excite the general public," explains Ted Lavine, staff physicist at the Stanford Linear Accelerator Center (SLAC) in Menlo Park, Calif., and project controls manager for the LSST project camera subsystem. "That's because these objects are potentially very dangerous for the Earth."

The new telescope's multiple images will also help astronomers trace (or detect) the presence of invisible lumps of dark matter, the gravity of which systematically distorts the apparent shapes of distant or remote galaxies by an effect called "weak gravitational lensing." This will enable searches for dark energy and will help astronomers better understand the physical nature of dark matter and dark energy, and why the universe is expanding at an accelerating rate. Much of the universe is made up of dark energy and dark matter, which humans cannot see with the naked eye and about which scientists currently do not have much information.

The LSST will be built on Cerro Pachón, an 8,800-ft.-high mountain peak in northern Chile. The goal is to start construction in 2010, see "first light" – that is, begin gathering digital images – in 2014 and run a science program based on the telescope from 2015 through 2025.

The project is estimated to require about five years to complete, cost $380 million and involve hundreds of people. It is managed by a nonprofit organization, Tucson, Ariz.-based LSST Corp., which serves as the single point of contact and collaboration for participating public and private organizations (see *A Great Partnership*).

EARLY STAGE ESTIMATING

Like any big project, the construction of LSST could be a nightmare if not for the expertise of those managing costs, resources and schedules. In 2004, to get started, LSST Corp. was established as a project management office (PMO), which in turn developed the LSST project management control system (PMCS) to support the estimation and proposal process by integrating a variety of management tools, such as Primavera software and ProPricer, a third-party cost-estimating software from Executive Business Services.

The PMCS enables management of information for the planning process of the massive construction project and must be ready to support management of costs and resources for the PMO when construction begins. "The PMO focuses on proposal and project management preparation and analysis for construction of three key technical subsystems: the camera, the telescope and site, and the data management system to process the 30 terabytes of data generated nightly," explains Thomas Frey. Frey, with Triad Project Management Services

A GREAT PARTNERSHIP

In 2003, the National Optical Astronomy Observatory; Research Corporation; The University of Arizona; and the University of Washington formed the LSST Corporation, a non-profit 501(c)3 Arizona corporation, with headquarters in Tucson, Ariz. Membership has expanded to include Brookhaven National Laboratory, California Institute of Technology, Columbia University, Google Inc., Harvard-Smithsonian Center for Astrophysics, Johns Hopkins University, Kavli Institute for Particle Astrophysics and Cosmology - Stanford University, Las Cumbres Observatory Inc., Lawrence Livermore National Laboratory, Princeton University, Stanford Linear Accelerator Center, The Pennsylvania State University, University of California at Davis, University of California at Irvine, University of Illinois at Urbana-Champaign, and University of Pennsylvania.

In January, 2005, the LSST Corporation awarded a $2.3 million contract to the University of Arizona Steward Mirror Lab to purchase the glass and begin engineering work for the LSST's 8.4-meter-diameter main mirror. In September, 2005, the LSST received the first year of a four-year $14.2 million award from the National Science Foundation to design and develop this world-class facility scheduled for completion in 2014. As a public-private partnership, the LSST has also received more than $25 million in private donations to date.

For more information, visit www.lsst.org.

Corporation in Pasadena, Calif., is the project controls specialist and lead consultant for the LSST PMO.

SLAC's specific responsibilities center on the camera subsystem, including camera system engineering, system calibration, and environment and safety assurance. "We're currently in the design and R&D stage for the construction project that will build the scientific instrument," says Lavine.

Lavine and Frey work with the project managers and lead estimators of the three technical subsystems to define the project's scope, cost estimate and schedule in order to create a baseline for project execution. In the PMCS, the resource assignment view of Primavera lets project managers capture time-phased data by quarter, enabling them to evaluate the validity of cost estimates over time. This is especially important information to provide to funding agencies, such as the National Science Foundation. "Capturing time-phased data brings the dynamics of time into the cost analysis process," says Frey. "Communicating that data to stakeholders is key. If cost and schedule estimates are not integrated, a stakeholder could argue that it could cut funding by $20 million and not change the schedule."

The organization's goals for choosing the technology involved in preparing for project execution were as follows: find software that could accommodate multiple funding sources and collaborative organizations; use commercially available applications, if possible; and implement software in the planning stages that project managers could transition to project execution and that could eventually manage earned value analysis. And, of course, it had to be as simple as possible to use.

For the LSST PMCS, project managers use a standardized Microsoft Excel workbook form developed by Frey and Lavine for the cost estimate template. Use of the workbooks required training only for orientation to the form. The workbooks link to the Microsoft Access utility database, which processes the data from the workbooks and prepares it for both the Primavera and the ProPricer databases. The Primavera database enables the import of resource assignments, including labor hours and total costs, but not rates. ProPricer is used for cost extension and pricing, features built-in revision control, and manages

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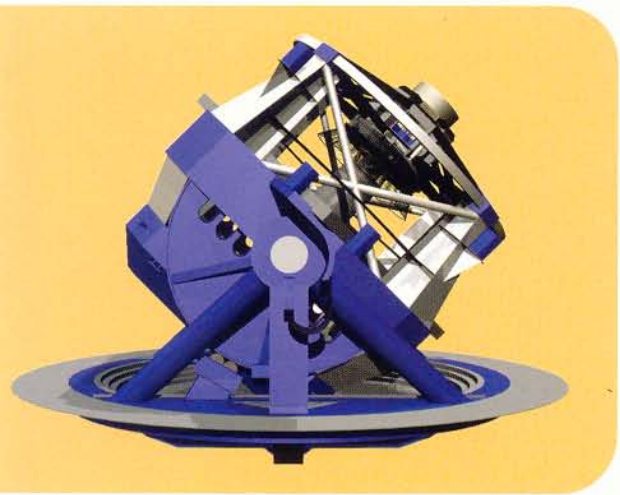
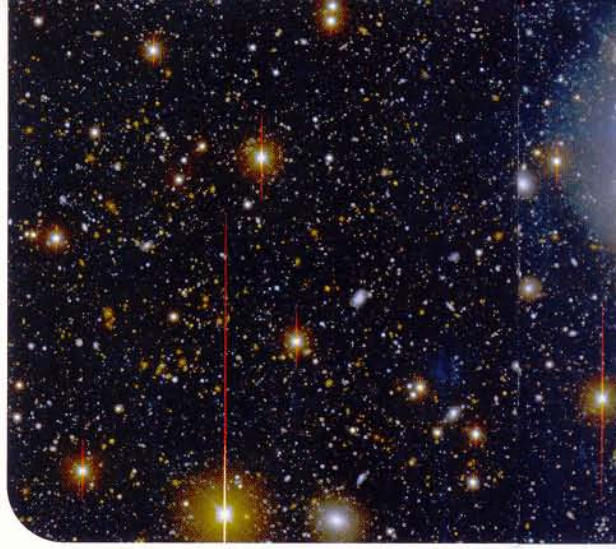


The proposed ground-based telescope will provide digital imaging of faint astronomical objects across the entire sky.



business rules and resource rates by pricing group. Project managers cross-check the resource information in Primavera against rate totals in ProPricer. "Because Primavera lets users define and reliably duplicate estimated resource information and cost information for planned activities," says Frey, "managers can use Primavera resource assignments to generate the data set that is used for error-checking, analysis and proposal support."

READYING RESOURCES

A resource dictionary in the PMCS keeps information about all resources needed, from contract information to travel costs to materials to hours. "All these projects are fairly labor intensive, and being able to estimate and analyze the hours over time is very important," Frey points out.

The PMCS supports reporting for the scope of the estimate (such as "complete design of the cryostat housing"), the basis of the estimate (such as "technician labor for testing at SLAC after receiving"), and risk assessment (such as a review of the technical, cost and schedule risk factors). In addition, "because the team has implemented Primavera now," says Lavine, "we will be able to use it for managing earned value shortly before construction begins." U.S. government-funded projects with a budget of more than $20 million are required to provide an earned value management system once they start.

To support a more traditional work breakdown structure, the team uses numeric project IDs. For activity codes, managers can use standardized codes whenever possible, but can create new codes if needed. "Key field IDs such as the activity ID, resource ID, and cost account are coordinated in the system to maintain integration between Primavera software and ProPricer," Frey explains.

Already, planning for the LSST project has resulted in 3,136 resource assignments across 553 activities, supported by an additional 2,242 activities. Those activities include everything involved in construction, from road construction through site excavation to general facilities construction and specialty facilities construction. Frey explains that specialty activities include constructing the telescope dome and mount; providing specifications for laboratories that have special requirements such as the need for clean rooms; developing the requirements for data management equipment; planning equipment procurement; and so on. "Parts of the project, such as the observatory itself, will be constructed in Chile," Frey says, "but many pieces of the telescope, particularly the highly technical items, will be constructed in the United States, so shipping is a key part of scheduling and resource estimation."

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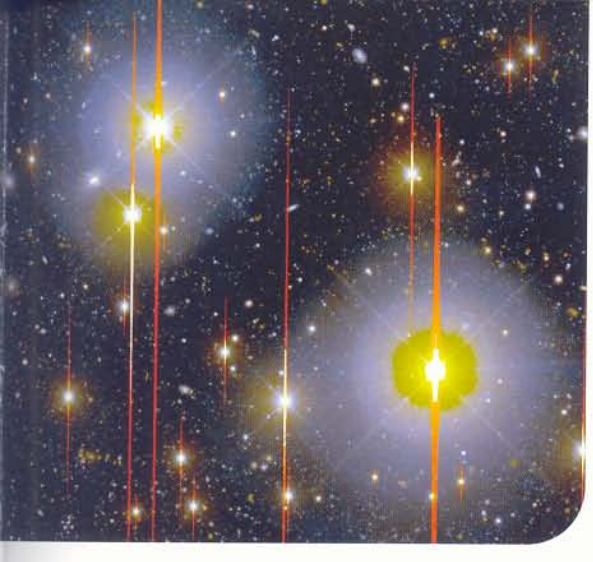
As of the writing of this article, the reference design for LSST was frozen. The cost estimate, pricing, scheduling and planning had been completed for



the construction proposal which, in January, 2007, was submitted by LSST Corp. to the National Science Foundation for the telescope, site facilities, and data management system. A coordinated proposal for the 3 billion pixel camera will be submitted to the U.S. Department of Energy by SLAC within a year.

The next steps for the PMO include continued support of the proposal process; continued refinement of the estimate and schedule through feasibility and constructability review, scheduled to be conducted by the funding agencies between now and 2009; preparation for execution of the project construction; and implementation of earned value analysis.

The project is still in its conceptual stages, but Primavera is enabling the PMO team to pave the way for project management when construction begins. "We're preparing to manage the costs and budgets," explains Lavine. "Right now, we're using Primavera to manage our interaction with funding agencies. It is currently used as an in-house tool, enabling us to make the data available to government organizations when needed," explains Frey.

As Lavine observes, "We have to estimate and propose all the costs and resources now for a scientific instrument that won't be built for more than three years. But in the end, Primavera will provide everything we need to know to help us manage the project." •

Roseann McGrath Brooks is a business and technology writer based in West Chester, Pa. Contact her at roseann.brooks@gmail.com.