A new generation of giant, optical/infrared (O/IR) ground-based telescopes is being born: observatories that will achieve revolutionary new limits of sensitivity and angular resolution, thanks to their huge collecting areas and to the capabilities of advanced adaptive optics. The Thirty Meter Telescope (TMT), Giant Magellan Telescope (GMT), and European Extremely Large Telescope (E-ELT) are moving forward with multiple-mirror architectures and diameters of 20 to 40 meters, which will enable new breakthroughs in subjects ranging from extrasolar planets to the formation of the earliest galaxies during the epoch of re-ionization. Each of these projects is an international consortium; and the national astronomy communities of Australia, Canada, Chile, China, India, Japan, Korea, and the European Southern Observatory member states will have access to one or more of these telescopes. At present the US community, outside of the universities that are members of TMT or GMT, is not yet formally a partner in any of these observatories. The last two decadal surveys of US astronomy gave national participation in a giant telescope high priority: ranked first among large, ground-based O/IR projects in Astro2000 and by the Astro2010 ground-based O/IR panel and third overall in the final Astro2010 report.

In 2013, the NSF and TMT entered into a cooperative agreement to formulate a plan for a potential NSF partnership in TMT. As a result of that agreement, several activities were initiated. NOAO established a US TMT Liaison office to develop this relationship. The US-at-large community now has equal representation on the TMT Collaboration Board and its Science Advisory Committee. A US TMT Science Working Group (SWG) was formed consisting of a dozen astronomers from institutions across the country who represent the US community’s interests, surveying its priorities and wishes, and developing a partnership concept for the NSF.

The current TMT partners each have subscribed shares of 10–20% of the telescope. The NSF could potentially join the project with a share comparable to that of the other international and US university partners. The US SWG has begun work on this participation plan. Throughout 2014 expect to hear from your SWG representatives, who will be asking about your scientific priorities, your interest in TMT instrumentation (as potential users, or as part of the teams that will build them), and your thoughts about observatory operations. What science programs would you carry out with TMT, and what instrumental capabilities would you need? How can TMT best complement the suite of other observatory facilities that will be operating post 2020? Should US observing time on TMT be classically or queue-scheduled, or some mix thereof? Should the US organize large science projects with some fraction of its time, or participate in internationally coordinated “TMT key programs”? What share of the TMT does the US need to be globally competitive in astronomical research?

At a TMT Town Hall meeting at the 223rd American Astronomical Society meeting in January, Michael Bolte (University of California, Santa Cruz) described the status of TMT: the state of the partnership and plans to start construction in the next few months of 2014, with first light planned for 2022. Mark Dickinson (NOAO) discussed the NSF-TMT cooperative agreement, introduced the US SWG, and described opportunities for US astronomers to become involved in TMT. You can view the Town Hall presentation at ast.noao.edu/system/us-tmt-liaison and follow continued
The TMT and the US Astronomical Community continued

the US SWG and its community engagement activities on Facebook at https://www.facebook.com/USTMTSWG.

This summer, NOAO will host the second TMT Science Forum (see accompanying box for details) for astronomers, educators, and observatory staff to explore TMT science, instrumentation, observatory operations, archiving and data processing, astronomy education, and STEM (science, technology, engineering, and mathematics) issues. Last year’s TMT Forum was a great success, with more than 50 astronomers attending from the US community at large, outside the University of California and Caltech partners. We will continue that conversation in Tucson. The Science Forum will include breakout sessions for the new TMT International Science Development Teams (ISDTs). The ISDTs are organized around eight themes, from exoplanets to cosmology, and advise TMT on science that guides the observatory development. They are open to participation from all PhD astronomers and will have annual calls for membership. For more information, watch the NOAO Newsletter, the NOAO Currents electronic newsletter, and the US TMT SWG Facebook page.

The LSST Project Prepares for Construction

Bill Gressler

The Large Synoptic Survey Telescope (LSST) Project has taken significant steps recently toward a federal construction start. LSST is the top-ranked, large-scale ground-based project for the next decade as recommended by the Astro2010 decadal survey report. The LSST Project passed its National Science Foundation (NSF) Final Design Review (FDR) in early December 2013. In addition, the omnibus spending bill signed by President Obama in January included language within the Major Research Equipment and Facilities Construction budget line that specifically allocated funds for the initiation of LSST construction in fiscal year 2014. Readers interested in the latest information about LSST should visit www.lsst.org and subscribe to the quarterly LSST E-News at www.lsst.org/lsst/news/enews.

The NSF convened a panel of 15 members to conduct the FDR for the LSST. The week-long review took place in Tucson, Arizona. The panel concluded that the project team is very strong, with well-developed plans, schedules, and cost estimates and declared that the project to be ready for start of construction on 1 July 2014. This crucial step moved the project closer to National Science Board approval of a construction start.

Also crucial to an LSST construction start is the identification of funding. The Consolidated Appropriations Act, 2014 includes $200,000,000 for Major Research Equipment and Facilities Construction (MREFC), the line in the Federal budget from which large projects like LSST are funded. The omnibus bill was accompanied by an NSF-provided Explanatory Statement in the MREFC section that stipulated: “Funds are provided at the request level for all projects for which construction has already begun, and remaining funds are for the initiation of the Large Synoptic Survey Telescope (LSST) project. If NSF determines that LSST requires additional funding in fiscal year 2014, NSF may submit a transfer proposal to provide such funds.”

The LSST Telescope and Site team has completed several early procurements of major telescope subsystems and made awards to vendors. Current awards include the M2 (the secondary mirror) Cell Assembly (ITT Exelis) and the M2 Hexapod and Camera Hexapod/Rotator systems (Moog/CSA Engineering). These early efforts support vendor-specific final design and risk reduction activities and will enable a swift transition into construction once authorization is received.

The M2 substrate is shown in Figure 1. The M2 Cell Assembly, shown in exploded view in Figure 2, includes an efficient steel mirror cell and active electromechanical support system.

The M2 Hexapod (see Figure 3) consists of a ring of six actuators that attaches the M2 Cell Assembly to the Telescope Mount to provide precise positioning about the telescope optical axis. The Camera Hexapod/
Rotator (see Figure 4) system likewise connects the LSST instrument to the Telescope Mount and provides for rigid body positioning and field rotation.

Additional procurements of the Telescope Mount Assembly (TMA) and the Summit Facility are planned for early 2014. The TMA is the largest single contracted effort of the Telescope and Site group and is depicted in Figure 5, integrated efficiently to the summit facility pier. This effort includes the mount structure, azimuth and elevation drives, a capacitor bank system to support the rapid settle and slew requirements, access platforms, and the camera cable wrap.

The Summit Facility procurement is being coordinated from Chile and will utilize the 100% facility design package (see Figure 6), which was completed in late 2013 by ARCADIS, an architecture firm based in Santiago, Chile. Initial construction activities will include final excavation to support road completion and structural design elements (see Figure 7).
LSST Project Prepares for Construction continued

The M1/M3 (primary/tertiary mirror) polishing effort is also nearing completion (see Figure 8), with final acceptance testing scheduled for mid 2014 at the University of Arizona Steward Observatory Mirror Lab. The mirror shipping/storage container has been fabricated and delivered (see Figure 9). The polished mirror will be stored locally in Tucson, awaiting completion of the active mirror cell system, which will be procured once construction is authorized. The M1M3 mirror will be integrated to its cell and retested optically prior to shipment to the summit for integration on the TMA.

The Data Management (DM) team has prototyped approximately 60% of the software functional capability. Over 350,000 lines of open source C++ and Python have been coded, unit tested, integrated, run in production mode on LSST simulated data and data from precursor surveys. The team has released three terabyte-scale data sets, including single-frame measurements, point source, and galaxy photometry. A significant portion of this software has been executed in parallel on up to 10 K cores—TeraGrid/Extreme Science and Engineering Discovery Environment (XSEDE) and the National Center for Supercomputing Applications (NCSA) Blue Waters hardware—with highly scalable results demonstrating that the DM System will scale to the data volumes necessary to provide annual LSST data releases during operations. In the area of giga-scale network design, the team is currently testing data transfers between Chile and the US at up to 1 Gbps, a 10-Gbps link shared with Dark Energy Survey and CTIO. Agreements in principle are in hand with key network and processing center infrastructure providers (NCSA, Florida International University/AMPATH, REUNA).

The LSST Project continues to grow to support the upcoming construction effort. In Tucson there were a number of personnel changes recently, including the addition of Bo Xin as Systems Analysis Scientist and Chuck Gessner as Head of Safety. Recruitment for several additional positions is planned for early 2014, including the Telescope and Site Scientist and Deputy Director. The month of December marked the inclusion of the 40th Institutional Member to the LSST Corporation as both Northwestern University and Oxford University gained official organizational membership. Finally, the Project anticipates another All Hands Meeting in August 2014, to bring together scientists and technical teams for a week of intense interaction, including a workshop on survey cadences.

Figure 7: LSST site (El Peñón) on Cerro Pachón in Chile.

Figure 8: Polishing of the LSST M1/M3 mirror at the Steward Observatory Mirror Lab in Tucson.

Figure 9: The delivered shipping/storage container for the LSST M1/M3 mirror.
Constructing TripleSpec 4: A New Infrared Spectrograph for NOAO South
David Sprayberry & Ron Probst

TripleSpec 4 will be the last new instrument built under the ReSTAR process for NOAO. Its construction is a partnership between Cornell University (Dr. Terry Herter, PI) and NOAO; Cornell has engaged the University of Virginia (Dr. John Wilson) to support the project. TripleSpec 4 will be a moderate-resolution, single-object infrared spectrograph designed to support a broad range of science with a simple format, operational robustness, and the following principal features:
- Simultaneous wavelength coverage of 0.8–2.4 microns
- Reimaging fore-optics to match the telescope f/# to the instrument
- Single, fixed collimator-disperser-camera unit (no moving parts)
- Resolution of R ~ 3000
- Slit width of 1 arcsec, slit length of 37 arcsec
- Pixel sampling of 1 arcsec = 2.4 pixels
- Integrated infrared slit viewer/guider with an approximately 4 × 4 arcmin field of view

The name of the instrument comes from the fact that three versions were planned originally. Two are in use: on the Palomar Observatory 200-inch Hale Telescope and on the Astronomy Research Consortium (ARC) 3.5-m telescope. The third is under construction at the California Institute of Technology (PI, Keith Matthews) for the Keck II telescope. The one for NOAO will be the fourth version, and it will be installed at the Cassegrain focus on the Blanco 4-m telescope at CTIO (Figure 1).

The TripleSpec 4 team is making good progress in the construction of the instrument. Cornell and the University of Virginia are sharing responsibility for the opto-mechanical assembly. Major subsystems being fabricated by vendors are well underway, and some are nearly complete. As of mid-January, Cornell expected to oversee acceptance testing of the instrument cryostat and the spectrograph camera in late January or early February. The grating (Figure 2), the cross-dispersing prisms (Figure 3), the collimator, and the lenses for the slit-viewing camera have already been received. The off-axis paraboloidal mirrors for the entrance relay are expected around April of 2014. Several machine shops, predominantly the on-campus facility at University of Virginia, are making good progress on the myriad of small parts that are needed for initial assembly of the instrument.

NOAO is responsible for the detectors, electronics, and the software to control and operate them. NOAO has completed the low-level control software and most of the higher-level user interface items. The H2RG detectors were received by NOAO along with a bare multiplexer (MUX) from Teledyne and the controller electronics from Astronomical Research Cameras. NOAO has operated the bare MUX at room temperature and achieved nominal performance as specified by Teledyne, thus verifying the design and execution of the software, cabling, and controller setup. NOAO has constructed a small test Dewar for cold testing and optimization of the detectors and is awaiting the receipt of the vacuum/cryo-qualified detector cables from a vendor. Cold-testing and optimizing the first detector should be completed by late April with delivery of this first detector-controller system to Cornell in May for their use in instrument integration.

Overall, some schedule time has been lost due to minor contracting issues, which led to a delayed start to the work at Cornell. Some of that lost time has been recovered, and Cornell and NOAO are cautiously optimistic that TripleSpec 4 will be delivered to CTIO in January 2015.